UNIVERSITY OF TARTU

Faculty of Social Sciences

School of Economics and Business Administration

Kateryna Grygorenko

TAKE-UP AND POTENTIAL BENEFITS OF E-GOVERNMENT SERVICES – AN EXAMPLE OF ESTONIAN ELECTRONIC SICKNESS LEAVE CERTIFICATE

Master's thesis

Supervisor: Andres Võrk

Tartu 2017

Name and signature of supervisor.....

Allowed for defence on.....
(date)

I have written this master's thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

.....

(signature of author)

CONTENT

Abstract

This paper examines take-up and potential benefits of one particular e-governance service in Estonia – electronic certificates for incapacity to work (E-TVL). In order to understand how the e-service of sickness benefits evolved and on what stage it currently is, we explore the take-ups of various e-service components. Take-up analysis is based on Everett Rogers' theory of the diffusion of innovations and Poisson regressions estimation results describing behavioural patterns. This study uses unique data aggregated from log files of Estonian data exchange layer X-Road. Results show that doctors have fastest adoption among all participants involved and higher take-up of electronic certificates is associated with older age groups. Employees characterized by slower adoption of E-TVL and clear gender pattern is observed: women of age group 20-30 y. o. on average access online portal 3 times more frequent than men.

Word count:137

Introduction

As information and communication technologies (ICT) are being applied more and more nowadays in order to improve public sector, it has raised a question about evaluating e-government initiatives. Providing a common approach or framework to assess benefits and costs of various e-government initiatives can help in improving e-government effectiveness.

There are a number of definitions of e-government provided by different institutions. According to OECD, e-government is defined as "the use of information and communication technologies, and particularly the Internet, as a tool to achieve better government" (OECD, 2013). The Internet offers new possibilities for governments to fulfil their functions better. Common definitions can be summed up to: e-government is based on the use of information and communication technologies in order to provide efficient government management, better service delivery and citizen empowerment through access to information (UN, 2014).

In the times of tight budgets, assessment of e-government benefits is a growing priority for governors, however there is not much progress so far in the development of appropriate measurement techniques. Resources spent on e-government projects have not been motivated by only financial return perspectives, but on the other hand, the goal was to offer better services to citizens/businesses (Intergovernmental Advisory Group, 2003, p.4).

In common practice, e-government initiatives, and particularly e-services, were implemented based upon policymakers' decisions, and no professional evaluation of impacts of these services and calculation of potential benefits has been done. It was rather seen as an advancement that will improve quality of services and efficiency of processes, so not much attention was paid to measurement of costs and added value created by public e-services.

On the contrary, evaluation of e-government policies based on the evidence could possibly result in more citizen-oriented, cost effective and performance-based evolution of e-government. There should be found a solution to addressed gaps and limitations in order to provide effective measurement of e-government projects, substantiate the investments required in its implementation, and eventually boost the creation of proper e-government initiatives with added value for all stakeholders (Stanimirovic and Vintar, 2013, p.304).

Studies demonstrate that advantages of measurement of e-government impact exceed ordinary calculation of costs and benefits or rate of return on investment of public e-service. Evaluation of e-government can assist governors with information about benefits and beneficiaries of government e-services and lead to better understanding of potential outcomes (OECD, 2005, p.102).

A big gap is observed between the supply and demand side of public e-services in majority of countries, which is substantiated as the "politically driven" initiation rather than "evidence based" evaluation and selection of e-government (Stanimirovic and Vintar, 2013). Gerpott et al. (2016) also point out about existing inequality between scope of e-government solutions offered to citizens and the take-up of these services by users. Most empirical research is based on studying supply side and availability of e-government.

Measuring the economic effects of public e-services is up-to-date and essential topic for Estonia and much of the world. Estonia's e-governance services are highly developed and comprehensive. According to UN E-Government Survey 2016, Estonia was ranked 13 in the world (out of 193 countries) for its progressive e-governance services, measured by E-Government Development Index. This opens many avenues for research as well as possible applications in other countries. It is important to study impacts of the X-Road as it makes up the core infrastructure that allows for interoperability between various registries, through which the country's economy is connected.

Governmental services in Estonia include e-service component. Core projects that are fundamental for functioning of Estonian e-government are X-Road and Estonian ID-card. "The X-Road and ID card are extremely important as infrastructure, because they have created the basis on which the remaining services have been developed, and they have often been the unavoidable prerequisite of various e-services" (Kalvet, 2013, p.4). Instead of creating one central system, Estonia decided to use open, decentralized system in which different services and databases are interconnected - X-Road.

The X-Road system was implemented in 2001, enabling the various government databases to communicate with one another and allowing government officials as well as individuals to access information in these databases. X-Road is the information system's data exchange layer. It was built as technological and organizational environment for secure exchange of data through Internet between information systems. For the state, X-road makes it possible for authorities to efficiently exchange data among themselves. "X-Road serves as platform for application development by which any state institution can relatively easily extend their physical services into an electronic environment. Therefore, X-Road offers a seamless point of interaction between those extending their services online and different state-managed datasets and services" (Vassil, 2015, p.11).

Philosophy behind X-Road is that every joining institution or any developed application can use the data stored in other repositories so that to avoid repetitive data

collection from the individuals. For this reason, X-Road creates incentives for the reuse of data.

No consensus has been reached so far about how to measure effects of implementation of e-government initiatives. From one point, not all of the effects and results of e-government are clearly visible. From other point, complexity behind concept of e-governance makes it hard to determine evaluation framework that can cover all aspects of e-government (Savoldelli et al., 2013, p.375-376). Therefore, there is a research gap of systematically defining methodology for evaluation of e-government. In this paper we want to address this issue by providing an overview of the possible methods found in the literature to evaluate e-government impact and summarize these methods.

Novelty of this paper implies that it studies the real case of governmental electronic service in Estonia and uses unique data generated by X-Road – data from X-Road log files. There has been no literature published yet about Estonian E-TVL service. This study is the first attempt to analyze electronic certificates for incapacity to work in Estonia (E-TVL), define its benefits and impacts. Since electronic solution was implemented for handling the system of benefits for incapacity to work in Estonia, this e-service was integrated into data exchange layer X-Road, all information is submitted electronically and stored in database. This paper also aims to contribute to literature by providing study of take-up of this e-service that is adoption of electronic certificates instead of paper ones.

Motivation: analysis of take-up is important, because it reveals whether supply side factors or demand side factors are more important in attaining full utilisation of the service. It also shows in what stage of the take-up the e-service is and how large might be the economic benefits when it is fully implemented.

In this paper, our **research aim** is to measure and explain take-up of one particular e-governance service – electronic certificates for incapacity to work in Estonia. This is used to illustrate potential benefits of this service. This study aims to contribute to the literature by first analyzing adoption of electronic certificates for incapacity to work, and particularly take-up of the e-service, statistically explain the use of electronic certificates by estimating econometric models. Also we provide calculations of Total Potential Value of the service to illustrate potential economics gains of implementing electronic sickness certificates instead of paper ones.

Therefore, **research tasks** of empirical part are the following:

- statistically explain the use of electronic certificates;
- analyze take-up of electronic certificates;

- illustrate potential economics gains of the e-service.

For this study we use statistical **data** from Estonian Health Insurance Fund, publicly available statistics from Statistics Estonia and log-files of the data exchange layer X-Road from 23 December 2003 to 31 December 2015. X-Road data contains information about queries made related to the e-service of obtaining certificates for temporary incapacity for work. Methodology for analyzing take-up of electronic certificates is based on Everett Rogers' theory of the diffusion of innovations. In order to illustrate utilisation of the e-service by age-gender, seasonality, trends we apply Poisson model estimation. Assessment of economics gains is done by bottom-up approach which allows calculating Total Potential Value per service.

The paper is structured as follows. Section 1 contains literature review. In Section 2 system of benefits for temporary incapacity for work and procedure of issuing electronic sickness certificates are described. Section 3 provides information about data and methodology applied in the empirical part. Section 4 presents empirical results: descriptive statistics of aggregated data, results of fitting curves for analyzing take-up, interpretation of econometric regressions, and calculation of potential economic gains. Section 4 is followed by discussion part. The last section concludes the paper.

1. Literature review

1.1 Impact of e-government and its measurement

Measurement of e-government impact is a novel topic. Although the topic of e-government is quite widely-spread in recent literature, there is a lack of unified methodology and established systematic knowledge about how to evaluate it so far. A number of studies (Berntzen, 2014; Codagnone and Undheim, 2008; Aichholzer, 2005) mention that impact evaluation of e-government services remains largely an under-researched topic. Codagnone and Undheim claim that there is a lack of a consensual paradigm and that "methodological pluralism will remain a characteristic of eGovernment measurement" (Codagnone and Undheim, 2008, p.14). Later study of Codagnone et al. (2013) still discusses that there is no consensus how to assess e-government outputs, outcomes and incomes.

Similar statement can be also found in publication of European Commission: billions of Euro have been spent by European governments to introduce online public services and implement e-government initiatives, however in most cases benefits and returns on investments have not been clearly quantified (EC, 2006, p.5). There is common agreement that implementation of ICT has led to positive change, but this has not yet been "documented and measured in a systematic way" (EC, 2006, p.5).

D. Stanimirovic and M. Vintar made a research of published literature which deals with measurement, assessment and evaluation of e-government policies and their effects. They found 51 relevant publications and grouped them into three categories (Stanimirovic and Vintar, 2013, p.296):

1) theoretical articles that contain conceptual framework for the assessment of e-government policies;

2) publications introducing pilot application;

3) indicator models with application in practice.

Impact of e-government is observed with respect to two groups – those costs and benefits accruing to government and those experienced by users. User costs and benefits arise for both citizens and businesses. From more general view, cost and benefits to society can be seen as a group of impacts. Lau (2005) proposes to distinguish impacts of e-government initiatives based on beneficiaries, to whom benefits are addressed:

- Business;
- Citizens (on individual level and society in general);
- Government.

Reduced administrative burden on individuals and firms is mentioned as one of the major benefits of e-government (Lau, 2005). Aichholzer (2005) mentions about less administrative burden for authorities and clients based on the case of online tax declarations and electronic record management system "ELAK" in Austria. Reduced bureaucracy is evident in many countries due to electronic filling of taxes.

Aichholzer (2005) analyzes impact of e-government in Austria, provides examples of online services in Austria and their benefits. Reduction of process time is evident for such e-services as issuing import licenses for goods, fully electronic tax declarations, electronic law making process (Aichholzer, 2005, p.101). All above-mentioned services have led to increased efficiency and reduced costs. One of the advantages identified about using e-government service was improved service – better and more flexible information access (Aichholzer, 2005, p.101).

Glassey (2010) makes attempt to find approach to assess e-services timesaving. He proposes to include the following components to the total time saved by e-service (Glassey, 2010, p.4):

1. duration of certain service performed by public servant;
2. time to fill in form by users (paper vs. electronic);
3. travel time needed to arrive to public institution;
4. waiting time (spent in queue);
5. lost time (due to missing forms, mistakes).

eGEP analyzed 70 different sources of the period 2000-2005 and found out that majority of them concentrated on e-readiness and on supply-side of e-government, and only few sources oriented on the user side (i.e. take-up, satisfaction with services) (Codagnone and Undheim, 2008, p.8).

Figure 1 illustrates that e-government activity is growing over time which leads to changes of the key aspects and, therefore, the demand for the benchmarking data is also changing its focus (Heeks, 2006, p.2). Focus of e-government benchmarking reports has shifted over time in the following direction: readiness – availability – take-up – impact. New emphasis on citizen or user centricity is evident since 2006 in literature (Codagnone and Undheim, 2008, p.8).

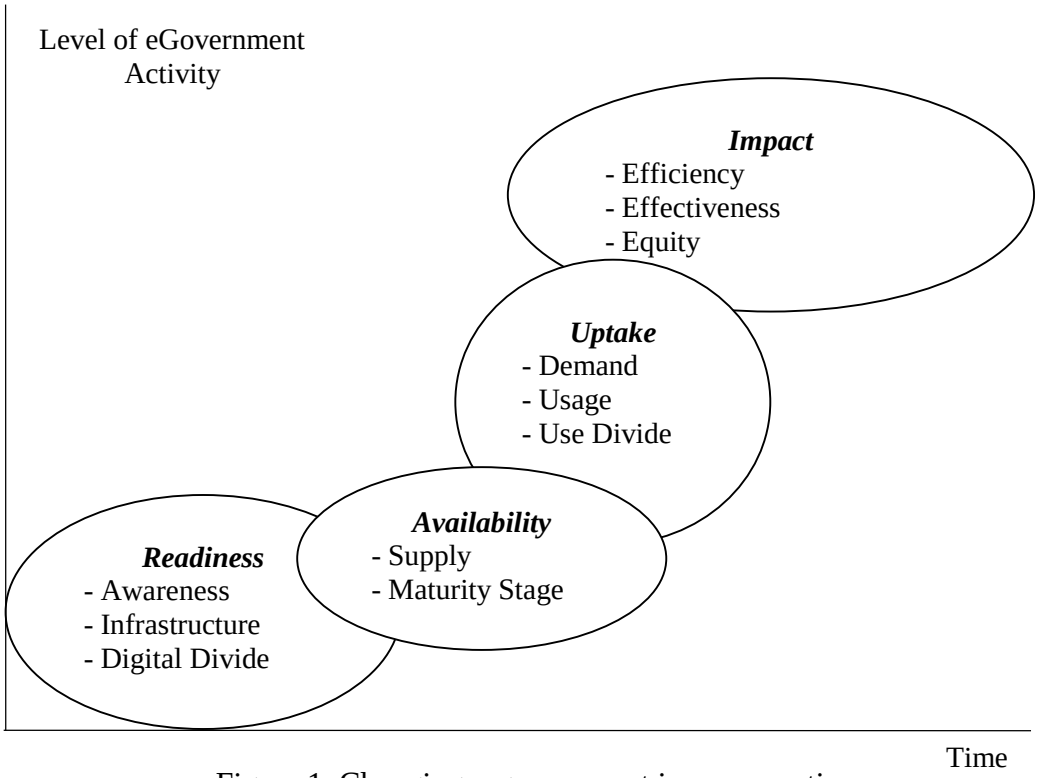


Figure 1. Changing e-government issues over time

Source: Heeks (2006), p.2

Measurement of impact is done at certain point in time. Because in another point in time in future impact will be different. Impact should be measured relatively to base time, time before the service was introduced (Berntzen, 2014, p.57). Berntzen (2014) finds it problematic that as long as impact is a function of time, the measurement of impact is only a "snapshot" of benefits evolving over time. On the contrary, we find it to be rather an advantage for researcher, because it enables to measure impact at certain point in time and, therefore, making estimate more accurate than it would be for a long-term perspective. As take-up of e-service is not constant and changing over time, which in turn influences development of e-service and its impact, it is more precise to provide assessment for concrete time.

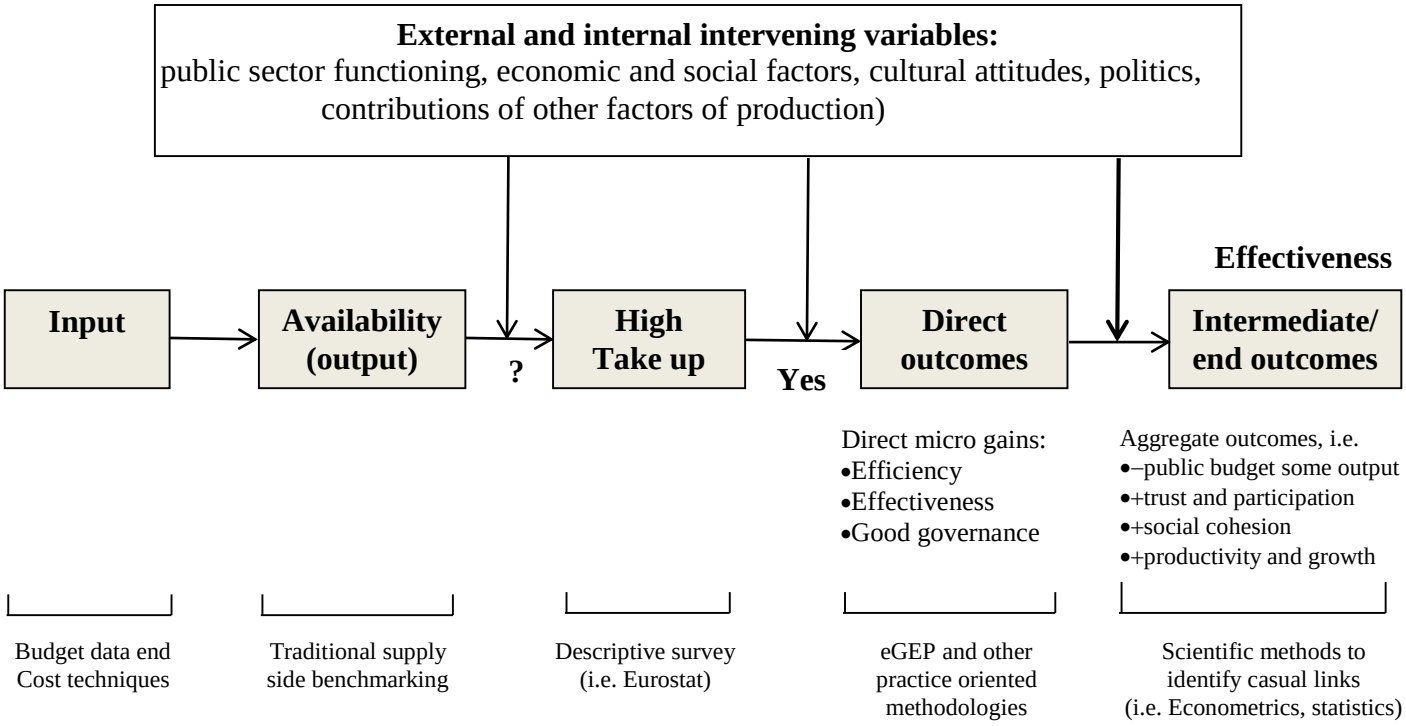


Figure 2. Measurement framework for e-government

Source: eGovernment Economics Project (eGEP), Measuement Framework, 2006

Measurement of public sector services operates with terms of input and output, effectiveness and efficiency, outcomes (Codagnone and Undheim, 2008). It is important to understand what is meant by these terms, relationship between them and their role in particular study. Therefore, we briefly describe the relationship between the terms.

Input are all the resources utilized for production of an output. Relationship between input and output is defined by efficiency. Efficiency answers question do benefits outweigh costs.

Link between output and outcomes is captured by effectiveness. Effectiveness is the relationship between desired and achieved results. Effectiveness answers question to what extent output meets the target.

In case of e-government, these terms are applied as well, but there are no precise definitions specifically for electronic public services. Output achieved by e-government is not considerably different from the one delivered in the traditional way. E- government is enabled by the use of information and communication technologies. However, technology by itself do

not produce an output. ICT can enhance existing processes, which can result in an increase of effectiveness and efficiency.

From the Figure 2, output of e-government is defined by actual provision of e-services, which represents supply side of e-government availability (Codagnone and Undheim, 2008). The extent to which the output can generate direct outcomes is determined by service take-up. Therefore, take-up is a precondition for direct outcomes of e-government.

Figure presents the idea that the further we move from input towards end outcomes, the more complicated the evaluation of e-government becomes. The further we move, the more outcomes are affected by external factors. Following this logic, providing measurement for outcomes is more difficult than for output since there are more influence of external factors to final outcomes.

Fitsilis et al. (2009) analyze different assessment frameworks of E-Government software projects. These are frameworks for quality assessment of information systems developed for e-government needs.

E-Government benchmarking is currently based on surveys carried out at international, supranational and national levels (Fitsilis et al., 2009).

Heeks (2006) defines benchmarking of e-government as study which analyzes comparative performance of e-government between nations or agencies. One of the main purposes of benchmarking is to provide information for policymakers about how well their country (agency) demonstrated e-government development and where it is placed in ranking comparatively to other countries (agencies) (Heeks, 2006, p.1).

Since impact of e-government often includes non-financial or intangible benefits, it is not enough to provide assessment of e-government based solely on financial metrics and quantitative indictors (EC, 2006, p.9). Traditional return on investment assessment does not fully reflect all potential public value of e-government. Therefore, qualitative measures should be included in e-government evaluation as well. All in all, measurement of e-government should include both (EC, 2006, p.14):

- quantifiable impact (in monetary terms);
- intangible impact (in qualitative terms).

In order to account for both quantitative and qualitative aspects, eGEP Measurement Framework was developed in 2006 under eGovernment Economics Project (eGEP) funded by the European Commission. This approach is mostly based on national measurement methodologies existed before (Danish, French, German, Dutch and British). eGEP framework aims to provide multidimensional assessment of social value potentially produced by e-

government and is oriented towards three aspects: efficiency, democracy and effectiveness (EC, 2006, p.3). These three dimensions are explained in Figure 1.

The eGEP framework was one of the first approaches trying to place both impact on users and quantitative outcomes (cost reduction, efficiency gains) into one measurement system of e-government (Codagnone and Undheim, 2008, p.8). Three divers of impact are efficiency, democracy (good governance), effectiveness.

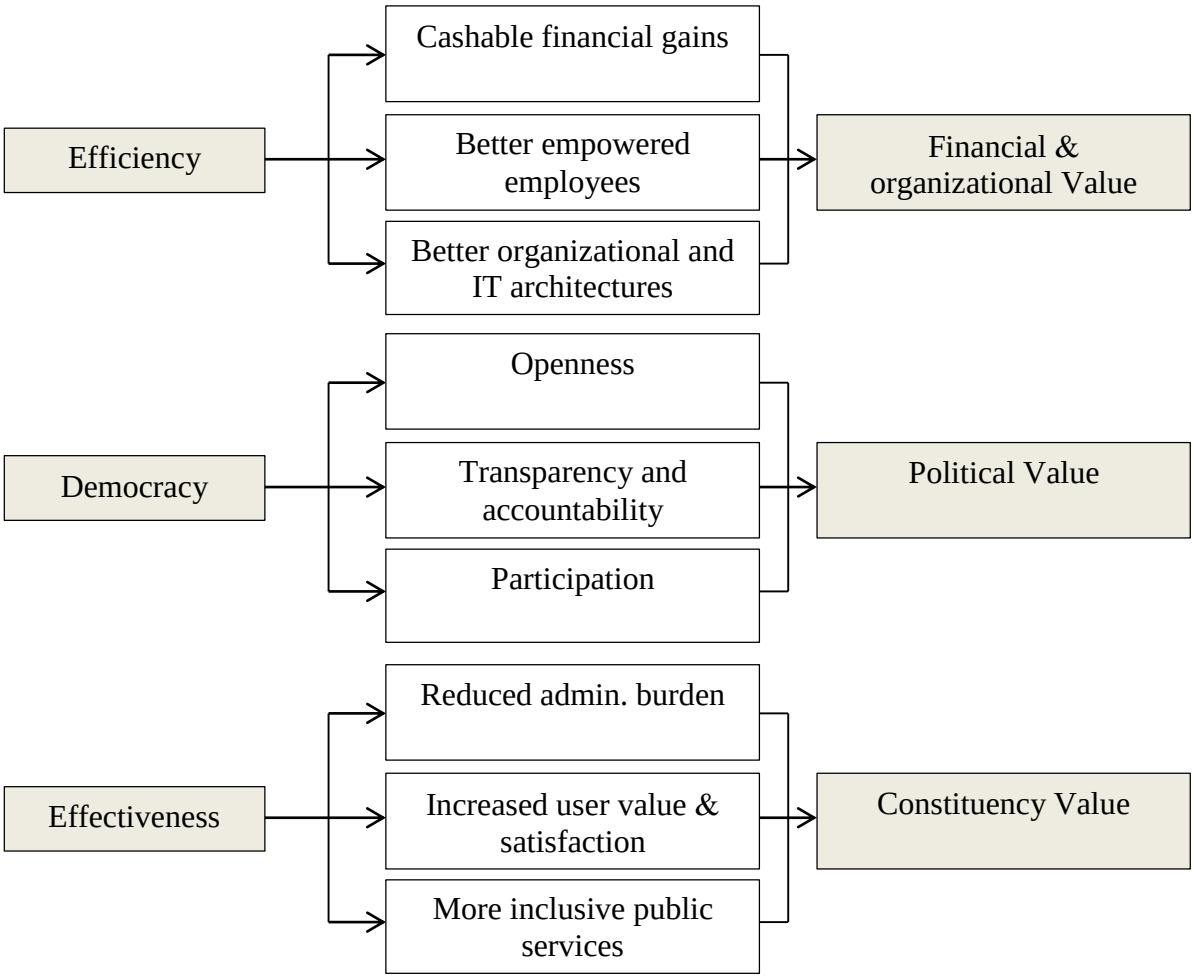


Figure 3. eGEP Measurement Framework Analytical Model
Source: eGovernment Economics Project (eGEP), Measuement Framework, 2006

Stanimirovic and Vintar (2013) proposed Integrated Indicator Model for the evaluation of e-government policies. The conceptual model is viewed as complex evaluation process, where e-government initiatives are placed in the counterpoint between the aspects

and levels of evaluation. The basic framework of an integrated indicator model is derived from the introduced conceptual model comprising five evaluation levels, which could be regarded also as different objects of the evaluation: project, organization, program, sector policy and territorial-administrative unit. Furthermore, each level can be assessed from four different evaluation aspects: organizational, infrastructural, political-sociological, and economic and sustainability. Therefore, different sets of indicators are needed for each aspect at each level.

There are also benefits of larger scope or **macroeconomic impacts** of e-government. These include reduction of corruption, creating openness, increase of trust in government (OECD, 2005, p.16). Implementation of e-government boosts social and economic development because it leads to better access to government services and improved quality of this services. Moreover, effective use of e-government improves linkages between government agencies as they can access and exchange data electronically.

Introducing e-government is important, because it improves efficiency of services and public administration operations. Use of Internet enables improvements of larger scale data collection, its sharing and transmission within government.

Also one of the benefits mentioned in literature is that e-government initiates more interactive partnership with the citizen-user. Innovations in public services stimulate tighter interaction between administrations and citizens and give individuals more opportunities to involve in development of these services (Djellal et al., 2013, p.103). On the other hand, public bodies frequently implement e-government in response to citizens' requests to "reduce administrative burdens" (Gerpott et al., 2016).

E-government programs provide benefits to a government in the following areas:

1. "Financial: Reduced costs of government operations/enhanced revenue collection
2. Economic development
3. Reduced redundancy: Consolidating and integrating government systems
4. Fostering democratic principles
5. Improved service to citizens and other constituencies" (Intergovernmental Advisory Group, 2003, p.9).

"Implementation of e-government policies significantly affects public sector organizations in terms of changes in organizational structure, business processes and organizational culture at organizational and inter-organizational level" (Stanimirovic et al., 2013, p.295).

Non-financial assessment methods of e-government include the following:

- KPI (key performance indicators);
- Benchmarking;
- Capacity check.

Financial assessment methods of e-government are as follows:

- NPV (net present value)
- ROI (return on investment)
- IRR (initial rate of return)
- VA (value assessment methods)
- BA (break-even analysis)
- CBA (cost-benefit analysis)

Majority of OECD countries, which have made e-government assessment, have used simple return on investment measurements such as net present value, internal rate of return and savings to investment ratios. These studies concentrate on government costs and benefits, because they are "controllable" and because it is easier to collect the relevant data (OECD, 2005). More complex methodologies developed by Australia, Finland, the United Kingdom and the US incorporate methods for estimating costs and benefits to users. The calculation of user costs and benefits is much more complicated owing to problems in producing a monetary or other value for issues such as better service quality or savings of user time.

1.2 Analysis of take-up of e-government services

Take-up analyses e-government from demand side, supply side is number of e-services provided by government and their quality. Codagnone and Undheim (2008) argue that outcome of e-government is reflected in statistics of actual use of services online resulted from take-up, rather than in availability of e-services (assessed by EU benchmarking). What it available for take-up analysis is descriptive statistics from surveys.

Often when electronic public services are being implemented, traditional channels of delivering the service are still operating (telephone, post etc.). It is a choice of users either to continue using traditional delivery channels of government services or switch to electronic services. Therefore, it raises question about take-up of e-government services as the new

electronic channels become available. And such migration of users from traditional channels to electronic ones is called take-up (Lau, 2005, p.3).

Take-up of the e-governmental service is an increase of number of people who use government services online in comparison to the other channels, e.g. paper or telephone. Take-up is accepting new format of service and, as a result, its wider use. Take-up leads to expansion of users of new technology. In other words, take-up is the adoption of new emerging service.

Take-up of the e-service can be theoretically described as diffusion of innovation. Diffusion of innovation as a theory was popularized by Everett Rogers. This theory aims to explain the process how the new technology is spread and at which speed. Diffusion is a process when an innovation is spread over time among its users (Rogers 2003, 5th ed., p.5). Outcome of diffusion is the adoption or rejection of the innovation. According to this theory, four main aspects affect the diffusion of new technology (idea): the new technology (idea) itself, communication channels, time and social system.

Rogers defines five types (groups) of adopters based on their degree of innovativeness:

1. Innovators;
2. Early adopters;
3. Early majority;
4. Late majority;
5. Laggards.

Table 1. Classification of adopters by E. Rogers

Group of adopters	Description
Innovators	Innovators are highly proactive in terms of using new technologies, risk lovers, financially secure, have access to scientific sources. They are the first ones to adopt new technologies. Being risk lovers allows innovators to use technologies that could be not successful in future. They represent the smallest group of individuals in society.
Early adopters	Early adopters are opinion leaders in society, have top social status, financial resources, higher education. These individuals are more selective which technology to adopt than innovators.

Early majority	Early majority start using new technology later in time than early adopters. These individuals have above average social status and they communicate with persons who are early adopters. They represent larger group of individuals in society than early adopters and innovators.
Late majority	Late majority start using new technology after the average individual has adopted it. They are characterized with high level of scepticism toward new technologies and adopt it only after bigger half of society are using this technology. They have below average social status, less financial recourses and do not considerably influence opinions in society.
Laggards	Laggards are the last individuals in society who start using new technology. They are risk averse, stick to "traditions", older in age among other groups of adopters, have lowest financial resources and tend to communicate within family circle.

Source: Based on Rogers 2003, 5th ed.

Cumulative adoption rate graph takes S-shape (Figure 44) because it sums up rate of adoption for different population groups (innovators, adopters, laggards etc.) provided that this is population with a normal distribution of innovativeness. Innovativeness is the extent to which a user adopts new technology (idea). Because size of above-mentioned groups of adopters is normally distributed in society, according to Roger's theory, the cumulative adoption function will be in the form of S-curve. S-curve can be mathematically defined as a logistic function.

Cumulative adoption rate implies that at certain point in time innovation will be fully spread or reach critical mass (reaching 100% of adoption).

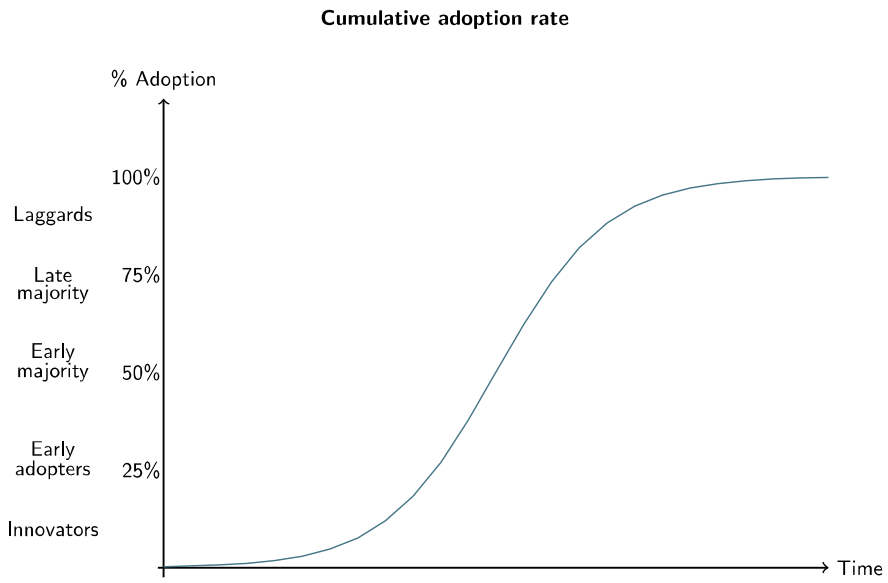


Figure 4. S-curve of cumulative adoption rate

It should be noted that there is a difference between what adoption and diffusion terms stand for. Adoption is a process on individual level starting at the moment when user first becomes aware of the service until fully adopting it. Diffusion is associated on level of the group of individuals and suggests how new technology spreads. Modelling diffusion is important because it gives useful knowledge about the rate of adoption of e-service at a specific time, the cumulative number of adoptions, possible life cycle of innovation.

2. Implementation of electronic certificates for incapacity to work of the system of benefits for temporary incapacity for work

In this paper, goal of the empirical part is to provide assessment of e-governance electronic service based on example of system of benefits for incapacity to work in Estonia. Electronic solution was implemented in Estonia for the system of benefits and it was integrated into data exchange layer X-Road. Key transformations of such solution to the system of benefits which existed before is that a certificate for incapacity to work becomes electronical, all information is submitted electronically and stored in database, provided information can be accessed online via state portal www.eesti.ee. Therefore, we use as object of study e-service of electronic certificates for incapacity to work in Estonia.

This electronic service was implemented fully. It started with voluntary use of electronic certificates for temporary incapacity to work which enables take-up analysis. Finally, take-up was fully reached in this particular e-service with almost 100% of doctors switching to issuing electronic certificates instead of paper ones.

Currently there are no academic articles analyzing electronic certificates for incapacity to work of Estonia. This paper is the first study to raise the topic of assessment of e-service concerning benefits for temporary incapacity for work in Estonia. Therefore, our paper aims to contribute to the literature by analyzing implementation of electronic certificates for incapacity to work and impact of this e-government initiative.

In this section we would like to present brief description of system of benefits for temporary incapacity for work in Estonia. Information is included about types of benefits which are compensated for insured person; when electronic certificates were implemented; process of issuing both paper and electronic certificates; advantages of implementing electronic certificates for various participants.

"The benefit for temporary incapacity of work is monetary compensation paid to insured persons on the basis of a certificate of incapacity of work" (EHIF[1]). The benefit is paid to the employed person who is insured. There are four kinds of benefits for temporary incapacity of work:

1. Sickness benefit
2. Care allowance
3. Maternity benefit
4. Adoption benefit

[1] Estonian Health Insurance Fund (EHIF)

Sickness benefit is paid to an insured person on the basis of a certificate of incapacity to work, when this person is temporarily on a leave from work. Sickness benefit cases include falling ill, work accidents, traffic accidents and domestic injuries. Sickness benefit from the EHIF is calculated taking for the base amount of social tax paid for the employee during the calendar year before the illness. When employer calculates sickness benefit, it is based on the average salary of the last six months.

Care allowance is a benefit, which is paid to the insured person, who has an ailing child or family member. Maternity benefit is applied to the insured woman who is on pregnancy or maternity leave. Adoption benefit is paid to the insured person on the adoption of a child under 10 years of age.

2.1 Electronic certificates for incapacity to work

E-TVL is an electronic certificate for incapacity to work in Estonia. E-TVL is abbreviation in Estonian for "elektrooniline töövõimetusleht", which is translated as electronic certificate for sickness leave. Before 2015, E-TVL and the paper certificate for incapacity to work were used in parallel (Figure). In fact, electronic certificates started to be used in practice already from September 2009, according to EHIF statistics.

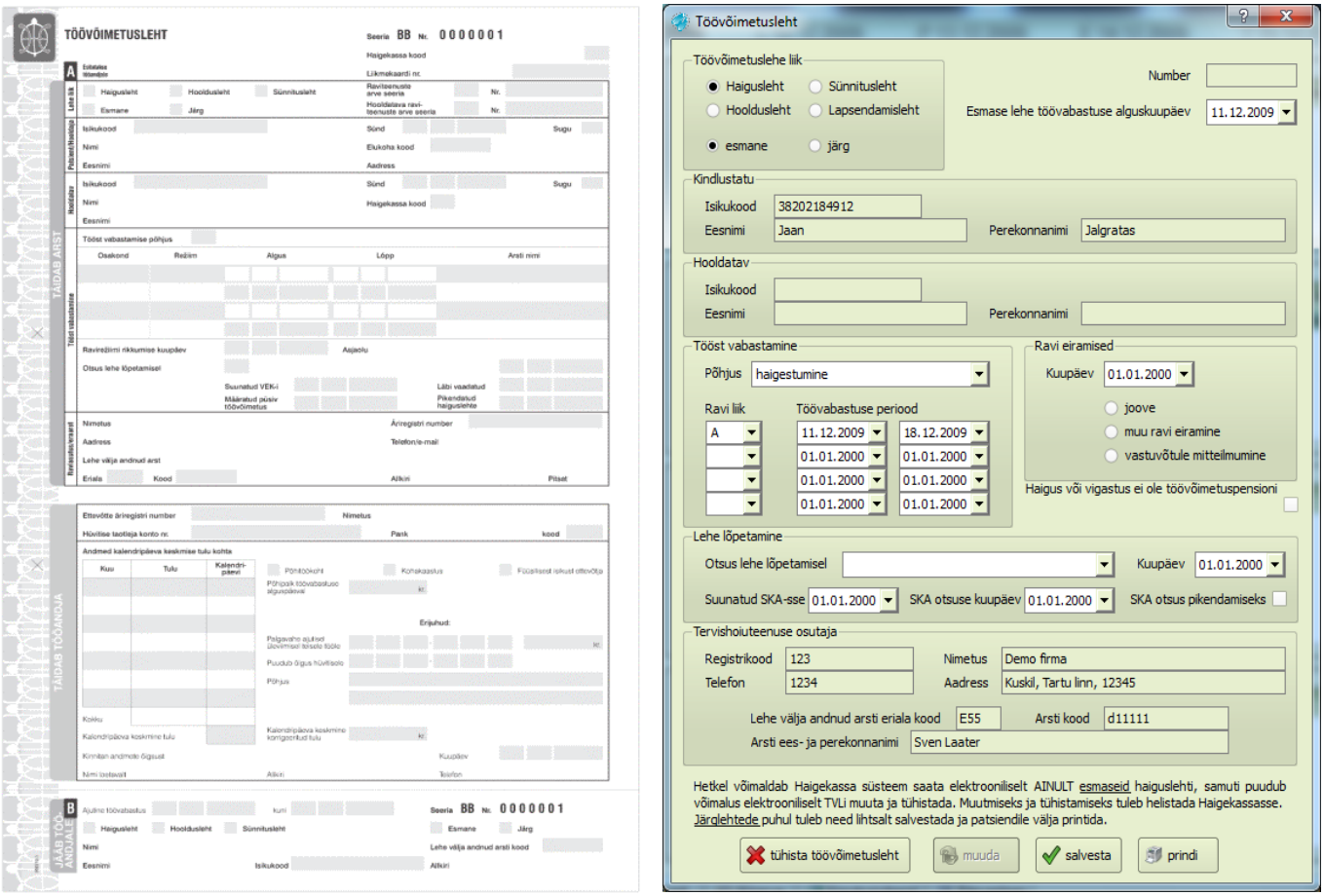


Figure 5. Paper and electronic versions of the certificate for incapacity to work

E-service of E-TVL is related to the bigger concept in Estonia's healthcare electronic solutions – E-Health. E-Health integrates data from different health care providers and creates profile for each patient. This system stores information on diagnoses, visits to the doctors, hospital treatments, prescribed medications etc. Another actively used e-service of Estonian e-health care system is E-Prescription, which is digital prescription for medicine.

Before introducing electronic realization of the existing service, sickness leave certificate was issued by doctors as a paper document. Doctors give this document to the employee, who later needs to bring it to his employer. In case when sickness benefit was paid by the employer, it was required to send a copy of the certificate to the Health Insurance Fund. In case when the benefit was paid only by the Health Insurance Fund, the original document must be forwarded to the Health Insurance Fund and employer keeps a copy.

If the insured person has several employers, doctor provides for the insured person as many certificates for incapacity for work as the number the insured person has employers[2]. In case when employer keeps the originals of certificates for incapacity for work, employer needs to submit to EHIF copies of the original documents together with required entries.

Nowadays, first, employee visits his doctor. At this stage, doctor issues sickness leave certificate electronically. In the end of sickness leave period, doctor in his computer formalizes and electronically submits sickness leave certificate for employee. This document is transmitted via X-road to the EHIF database. Employee can access submitted information by doctor via state portal www.eesti.ee.

Employer submits to EHIF additional data of the employee through state portal www.eesti.ee. When the employer has submitted the document through the portal, the employee receives the benefit a few days after the employer has submitted the data.

According to the amendment of the Health Insurance Act, § 53, since 1 January 2015 it became obligatory for all employers to electronically transfer data of the certificates for incapacity to work. At the same time, doctors are no longer issuing sickness leave certificates for patients in a paper form. Each employer needs to join the service in the state portal www.eesti.ee in order to access E-TVL service. Interface of the service for employers will show all the pending certificates for incapacity to work. Besides, employees can search their incapacity for work certificates on the individual basis as well by using the state portal.

[2] https://www.haigekassa.ee/en/news/changes-employers-payment-sickness-benefit

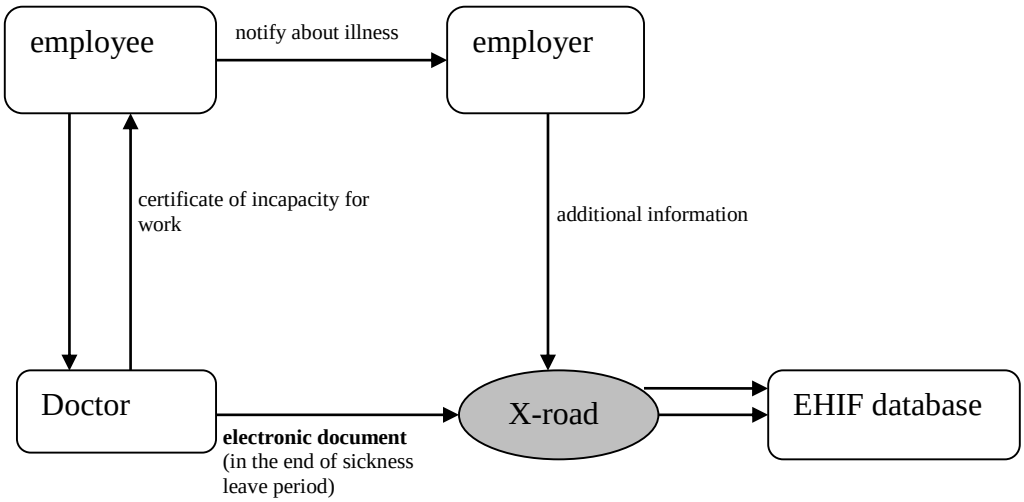


Figure 6. Procedure of issuing electronic certificates
Source: Author's own figure

Notes: Employees use X-Road service-components "tvl_loetelu_isik" and "tvl_loetelu2". Doctors use service-component "tvl_loetelu_arst". Employers use service-component "tvl_loetelu_ta".

2.2 Impact of E-TVL

E-TVL electronic service enables quicker payment of sickness benefit. Employer is no longer obliged to provide paper copies of documents to the EHIF, which in turn reduces postal expenses and time. Moreover, implementing this e-service considerably reduces administrative bureaucracy for doctors. In addition, employees do not need to keep and transmit paper copies of documents.

Sickness benefit is calculated on the basis of official salary. If person receives undeclared income, then the benefit will be smaller. Therefore, it provides incentive for employee to be involved in official economy. For this reason, this e-service can be seen as one stimulating transparency and reducing shadow economy.

Filling in electronic forms potentially leads to fewer occurrences of mistakes in future certificates and better quality of information provided. E-TVL enables much faster transmission of information. Implementation of the electronic certificates decreases chances of fraud and making false certificates, because the EHIF will provide data only to authorized users. Potential benefits after implementation of E-TVL e-service are listed in Table 2.

Implementation of electronic service makes procedure of issuing certificates for temporary incapacity for work clearer. Whole system becomes more transparent and healthcare governors can benefit from obtaining information directly from electronic databases and can instantly monitor the situation.

Table 2. List of potential benefits after implementation of E-TVL e-service

Parties	**Benefits**
Employees	Convenience

	Timesaving Quicker payment of benefits
Doctors	Less mistakes Timesaving
Employers	Resource efficiency Cost saving Less mistakes Timesaving Transparency
Society	Transparency, no fraud Ease of using services Reduction of administrative burden Quicker payment of benefits Trust

3. Data and methodology

In this paper we use data from three sources. First source is Statistics Estonia, from where we took publicly available statistical data for health insurance benefits. It includes statistics of number of benefits for temporary incapacity for work (including their types), number of compensated days, amount of payments from health insurance fund. It is yearly data from 1995 to 2015. We use this aggregated data for descriptive statistics of sickness benefits cases overall.

Second group of data was provided by Estonian Health Insurance Fund, which contains numbers of paper and electronic certificates issued, numbers of various actors involved (physical persons, doctors, employers). It is monthly data from January 2009 to December 2016. This data we used for analysis of take-up of electronic certificates.

Third source of data is X-Road log files involving E-TVL service. Log file is an automatic record occurring each time a user accesses certain e-service via X-Road. It contains information of time and date of access, user ID and which service was accessed. X-Road log data was aggregated daily for purposes of empirical analysis in this paper. Data consists of number of queries made through X-road regarding e-service of obtaining certificates for temporary incapacity for work. It also includes date of query, weekday and what service component was used. We have data as well concerning age and gender of user, who made the queries. It is daily data covering in total 12 years: starting 23 December 2003 until 31 December 2015.

Data obtained from X-Road log files has limitations due to gaps in logging, that is when logging system was down. It means that queries were not recorded during these days (Annex 1). This limitation we take into account by the help of Poisson regression using exposure.

In total 284336 physical persons and 2324 doctors have ever accessed service of E-TVL. 45% out of physical persons are men and 55% are women. According to age, population of physical persons is distributed that bigger half of it (60%) are young people 20 – 40 years old (Annex 2).

Take-up analysis in this paper is based on three sources of data and results:

1. statistics obtained from X-road data;
2. statistics provided by Estonian Health Insurance Fund;
3. Poisson regressions describing behavioural patterns (based on X-road data).

Methodology used includes methodology for analyzing take-up, Poisson regression models and bottom-up approach for each of three research tasks respectively. Methodology for analyzing take-up of electronic certificates is based on Everett Rogers' theory of the diffusion of innovations. For the purposes of studying adoption, we explore S-curve of cumulative adoption rate for different groups of users of E-TVL system by fitting logistic functions and looking at the trend of paper vs. electronic certificates usage.

To calculate potential benefits of E-TVL we adopt bottom-up approach from Van der Wee et al. (2015). This method is suitable for quantifying direct as well as indirect impacts of implemented project (technology). It measures benefits from individual level ("bottom") towards group level and aggregates it further ("up"). For this reasons, it allows to assess quantitavely benefits of one particular technology implemented. Therefore, we find it suitable to apply bottom-up approach for calculation of potential benefits of E-TVL implementation.

Furthermore, the bottom-up approach enables to more clearly link the monetary results to the individual effects (Damart & Roy, 2009). The advantages of bottom-up modelling include also clearer link between results and individual effects, more detailed results and a possibility of forecasting. Bottom-up approach was applied by Van der Wee et al. (2015) in order to measure indirect effects of broadband networks for e-government and e-business. Three calculation steps per effect were developed by the authors.

Firstly, calculation of the Total Value Potential (TVP) per service is performed that "indicates the maximum monetary value a certain service or effect could entail, independently of the market that adopts it" (Van der Wee et al., 2015, p.180). TVP per service is obtained by the following formula:

$TVP_i(t)$=population group$_i$ ×unit benefit [U]×conversion [€/U]×occurence (t)

Occurrence is how many times per year analyzed factor is observed.

The goal of the method is to distribute right monetary benefit to the right actor. Therefore, second calculation step is deriving Total Value per actor (TVP_a) per time period

provided information about the share of the actor and adoption curve of the service. It can be done according to the following formula:

$$TVP_a(t) = \sum_i TVP_i(t) \times \frac{share_{ia}}{\sum_i share_{ik}} \times AC_i(t) \quad ,$$

where $share_{ia}$ is a share of the corresponding actor;

AC_i is adoption curve of the specific service that reflects how fast the service is adopted over time.

The final step is finding impact of adoption of broadband networks that is the Total Value for all effects for broadband networks. It can be done by summing up all TVP_a multiplied with the adoption curves and the share taken up by broadband.

4. Empirical results

4.1 Statistical overview of temporary incapacity for work cases

In total, there were 359 thousand new temporary incapacity for work cases in 2015, which corresponds to the monetary amount of 116977 thousand euro of benefits paid by the EHIF. Figure 7 includes graphs of the number of cases of benefits according to their types.

About 2/3 of the number of cases constitute sickness benefits, while care benefits represent almost 1/3 of all temporary incapacity for work cases. Maternity benefits and benefits for occupational accident together constitute about 5% of all cases. In monetary terms shares of various types of benefits are distributed differently: 45% of total payments are paid as sickness benefits, 36% as maternity benefits, 3% as benefits for occupational accident and 16% as care benefits.

Graphs below presents dynamics of number of health insurance benefits according to different types of benefits (Figure).

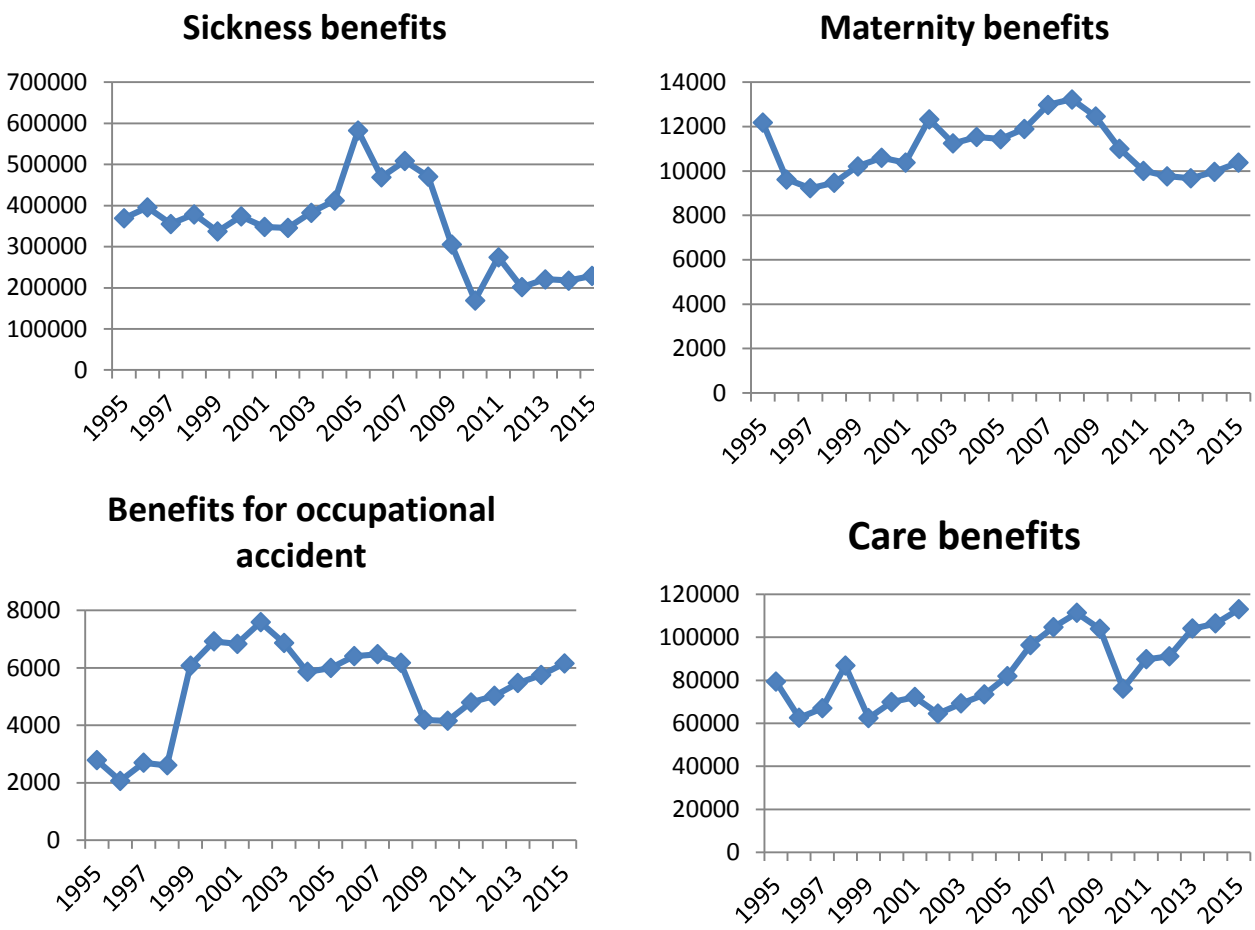


Figure 7. Number of benefits compensated by the EHIF according to their types

Source: Author's own figure based on Statistics Estonia data

From Figure, we can see dramatic increase in the number of queries starting from 1st January 2015 as the new amendment has come into force, which made electronic form of certificates mandatory. It can be also noted that there are some periods with gaps. For these periods we have missing information due to break-down of the logging system.

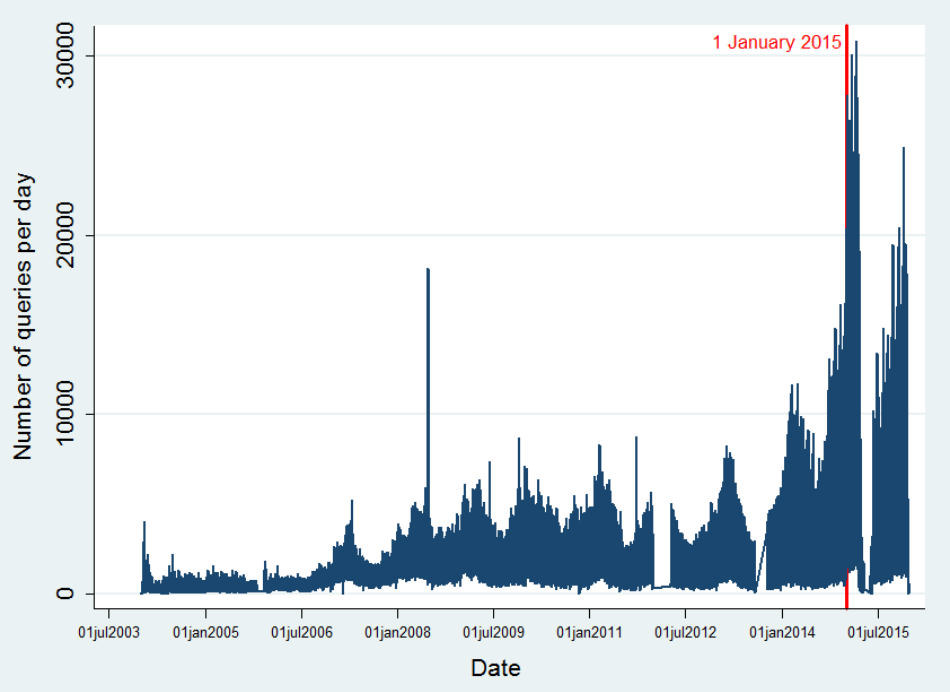


Figure 8. Number of queries per day

Source: Author's own figure based on X-Road data, daily aggregated

Graph of number of queries per month demonstrates that we have seasonality in our data, which suggests to incidents of contagious diseases, e.g. flu seasons. We observe peaks in the number of queries in January-February every year due to such "illness" seasons (Figure).

A detailed picture of different services-components can be seen from Figure10. It can be noticed that dynamics of number of queries is different for various services-components of E-TVL.

If we look at number of different persons who accessed e-service (maximum daily value corresponds to each month) we see clear seasonality monthly pattern as well (Figure 11). Number of persons increases in peak seasons and decreases in the rest of seasons. Starting from January 2015 we observe considerable jump in number of persons who accessed e-service due to switch to electronic form, which became mandatory for all employers.

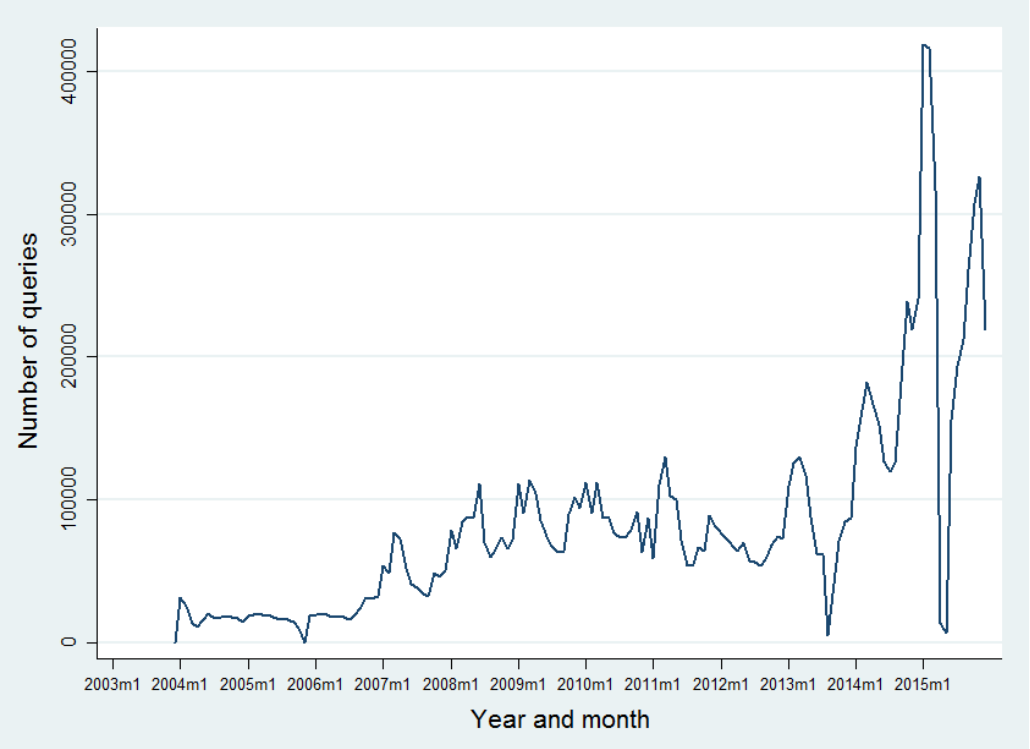


Figure 9. Number of queries per month

Source: Author's own figure based on X-Road data, monthly aggregated

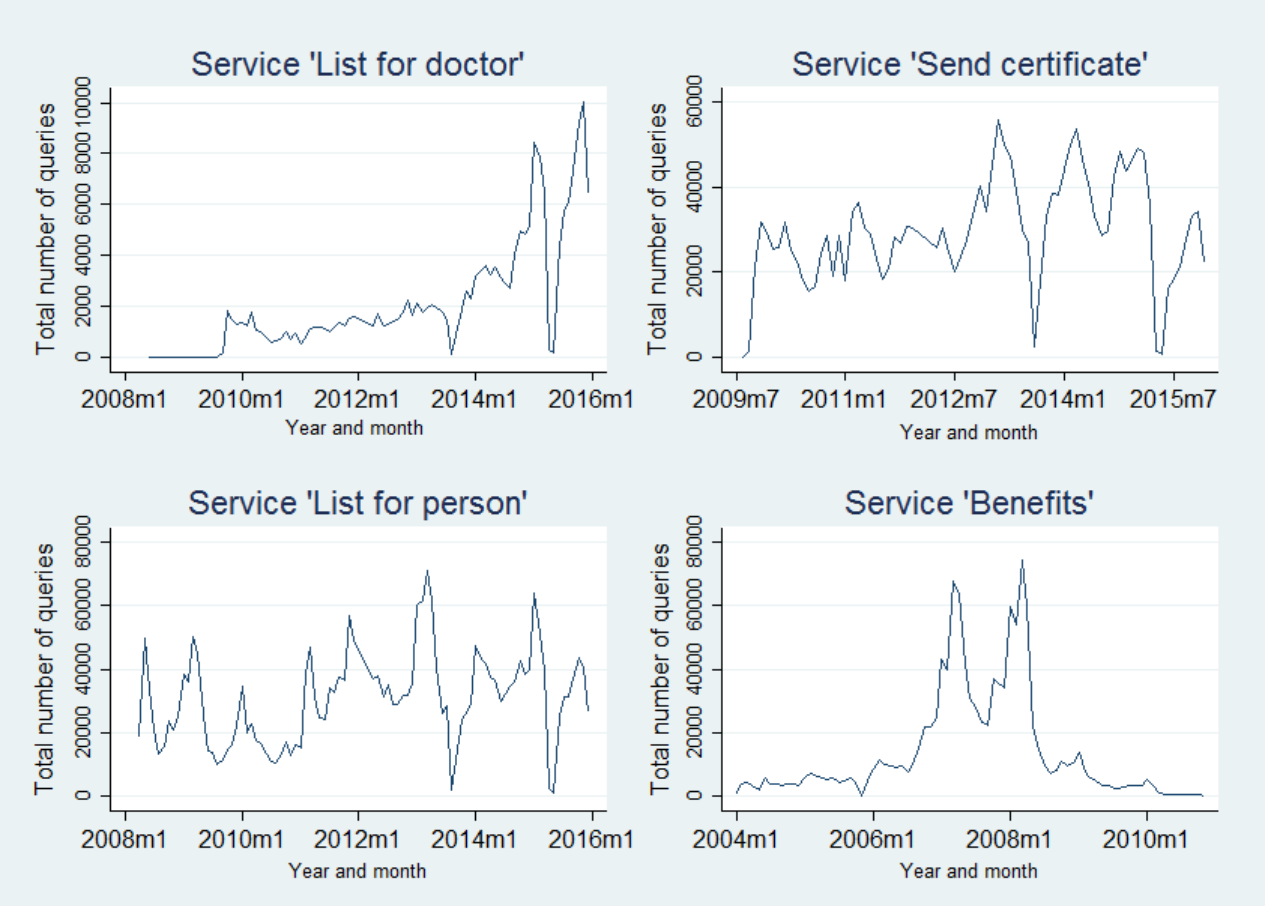


Figure 10. Total number of queries each month for different services-components
Source: Author's own figure based on X-Road data, monthly aggregated

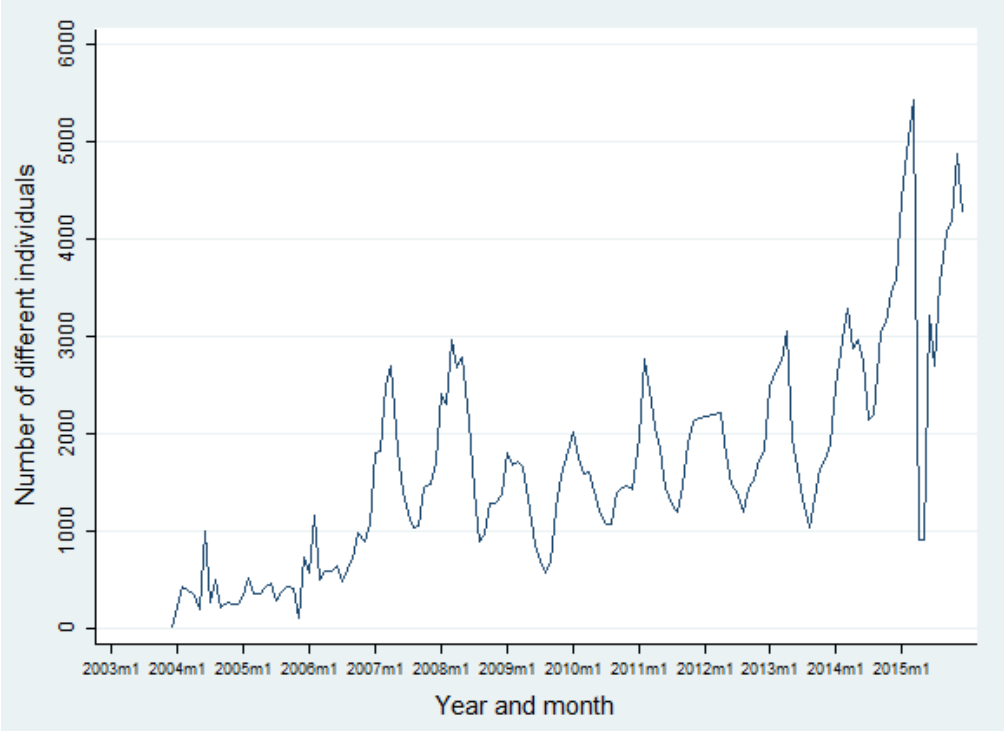


Figure 11. Number of different persons who accessed e-service (monthly)

Source: Author's own figure based on X-Road data, monthly aggregated

From Figure 11 we can see number of different users who accessed E-TVL each month. However, we should distinguish between these users. Therefore, we build graphs separately for physical persons that are employees who check their benefits online (Figure 22) and doctors who either issuing new E-TVLs or accessing existing ones (Figure 33).

Increased dynamics in the period 2006-2008 is justified by the larger amount of benefits issued. While in 2007 there were 632531 benefits for temporary incapacity for work and 601651 benefits in 2008, in 2010 this number was only 260693.

Number of different doctors who used E-TVL was slowly growing since 2010. Each month e-service was accessed by up to 1500 different doctors. Rapid drops on the graph are due to not working logging system.

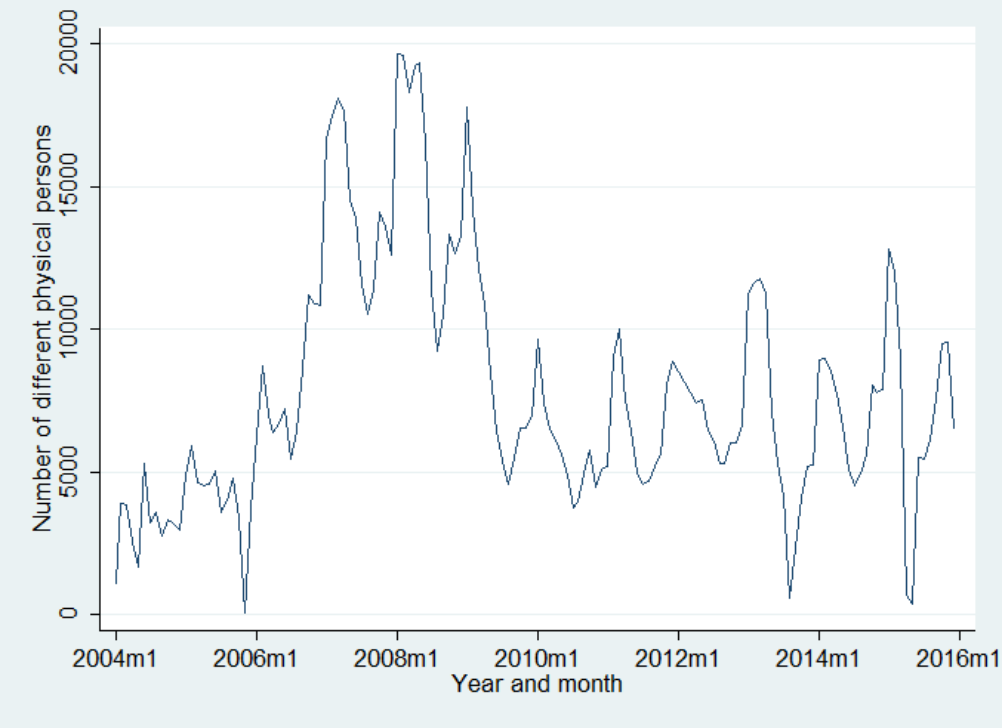


Figure 22. Number of different physical persons who accessed e-service

Source: Author's own figure based on X-Road data, monthly aggregated

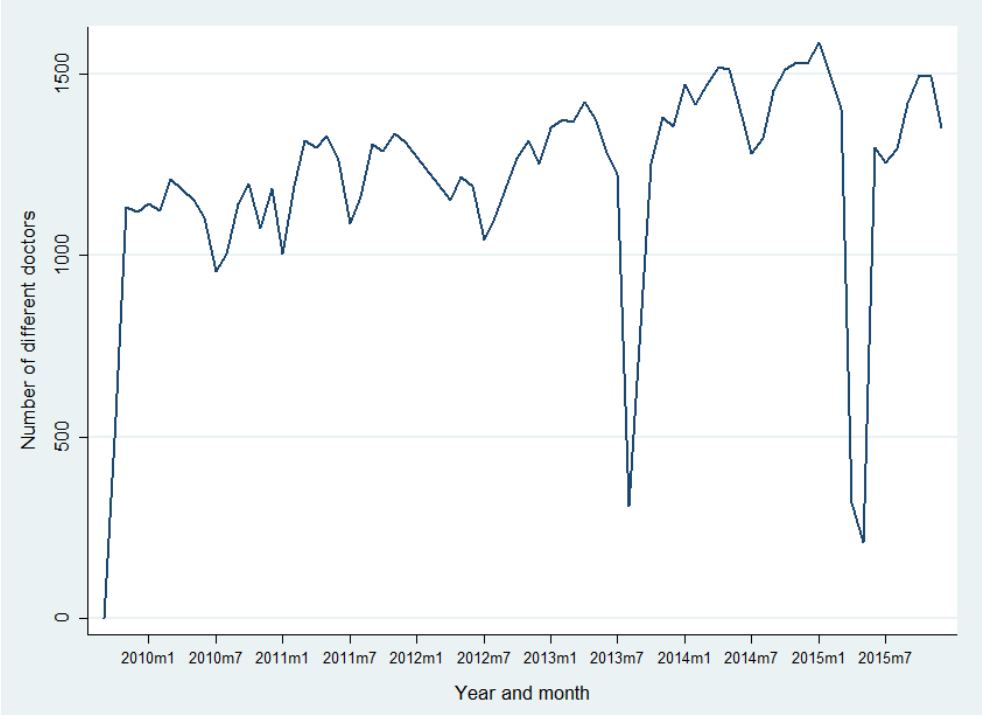


Figure 33. Number of different doctors who accessed e-service

Source: Author's own figure based on X-Road data, monthly aggregated

4.2 Take-up of the e-service of sickness benefits

Analysis of take-up is important, because it reveals whether supply side factors or demand side factors are more important in attaining full utilisation of the service. It also can

demonstrate in what stage of the take-up process the e-service is and how large might be economic benefits when it is fully implemented.

In order to understand how the e-service of sickness benefits evolved and on what the current adoption of electronic certificates is, we need to explore the take-ups of various aspects of this service. Therefore, we analyze take-ups by fitting S-curves to our monthly data for different service-components (as described in theoretical part, section 1.2). S-curve is a cumulative adoption function, that we estimate as a function of logistic form.

Before electronic sickness certificates were made compulsory in Estonia (January 2015), doctors have voluntarily chosen to use either electronic or paper version of certificates. Electronic sickness certificates in Estonia started to be issued already from September 2009 (Figure 14). Even before E-TVL was introduced, it was available for employees to check information about their benefits online. Therefore, it provides opportunity to study take-up of E-TVL with respect to two groups of individuals: doctors and employees, and analyze adoption of this e-government service.

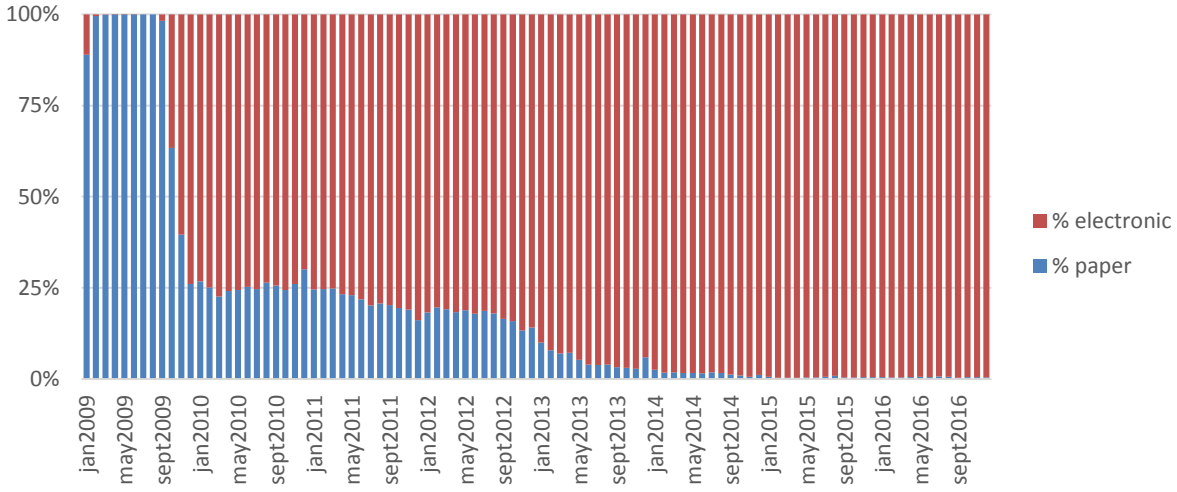


Figure 14. Share of paper vs electronic certificates issued (2009-2016)

Source: EHIF Data

From graph below (Figure 47), we can see different service-components and observe take-up in accordance to various actors – doctors, employers and physical persons. It could be mentioned that fitted curves for take-up have different shapes. Doctors tend to have faster take-up of E-TVL service as the curve is steeper. Rapid take-up for doctors can be explained partly due to common use of computers and patients databases in Estonia (E-Health), when doctors are already accustomed to use computers in their daily practice. From Figure 15 we can see how the popularity of paper certificates has gradually decreased over time and

adoption of E-TVL started to spread among doctors. Already in the beginning of 2010 more than 80% of doctors issued electronic certificates. In January 2011the adoption level reached 90% and slowly continued to increase after.

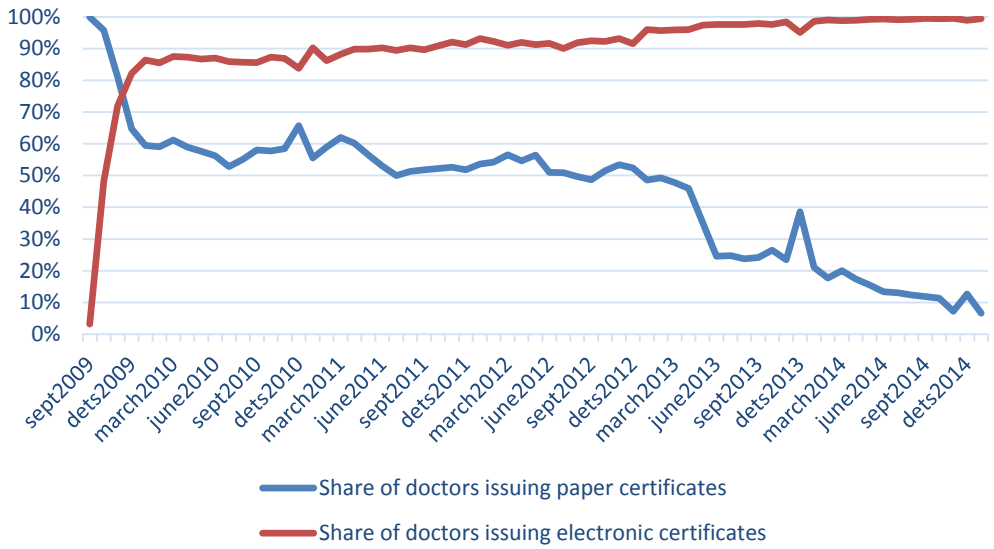


Figure 15. Share of doctors issuing paper and electronic certificates
Source: EHIF Data

Fast take-up of e-service by doctors is also supported by survey results. Estonian Health Insurance Fund has studied health care providers' satisfaction with various aspects of health care arrangement. In 2012, the survey asked their opinion about electronic system of forwarding sickness certificates[3]. The results showed that most health care providers were satisfied with the system (Figure 16). 85% of family doctors were either very satisfied or rather satisfied with the system. It was even higher for special care providers (100%) and dental care providers (94%).

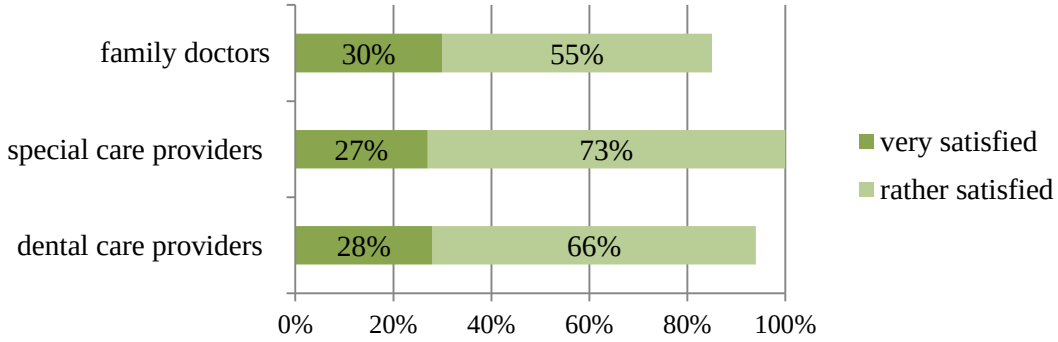


Figure 16. Survey results about satisfaction of transmitting E-TVLs

Source: EHIF Report 2012

[3] http://haigekassa.ee/uploads/userfiles/HK_partnerite_uuringu_raport_21_02_2012.pdf, p.57

Employers have take-up regarding adding information about employees described by the curve, which has peak in 2015 as most likely majority of employers had experienced usage of E-TVL at least once by this time and after that take-up has downward trend because next months there were simply less certificates to submit information for. Employees appear to have slower take-up. Take-up by employees is not that high as for other actors because not all people necessarily check their sickness benefits online.

The average number of employees checking their sickness benefits via state portal annually is around 50000 people, which is only 18% of physical persons who have ever accessed service of E-TVL.

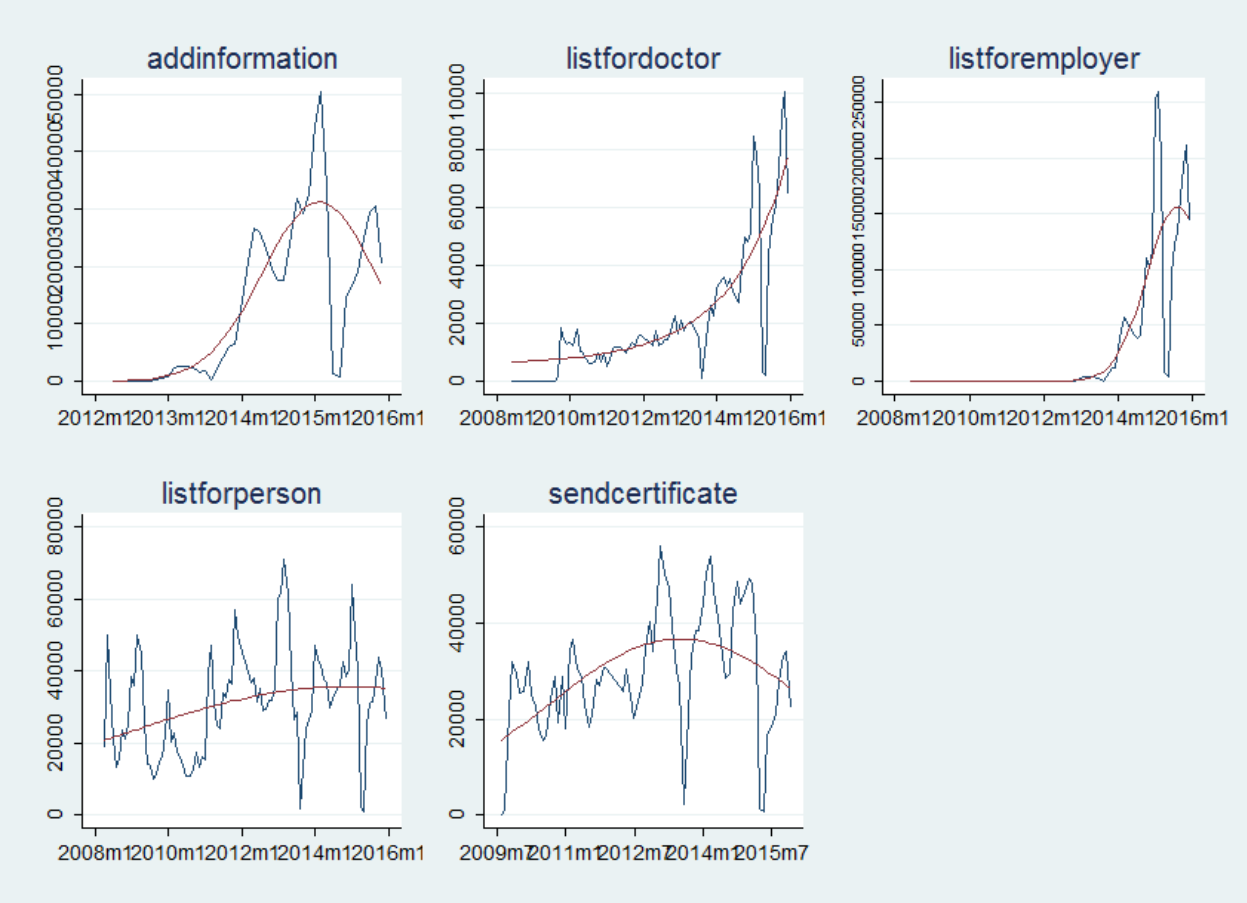


Figure 47. Take-up of different services-components of E-TVL

This is estimation with non-linear least squares by fitting the following logistic function:

$$y_i = \beta_1/[1 + \exp\{-\beta_2 (x_i - \beta_3)\}] + \epsilon_i$$

Result of fitting it to the data of the service-component "List for employer" (see Annex 6) provides the next function:

qperday=4948/[1+exp(-0,33*(monthyear - 654))] ,

where qperday is the average number of queries per day in the days when server worked;

monthyear is the time variable indicating month and year.

This function explains 78% of variance of the data. All β coefficients are significant at 95% confidence level.

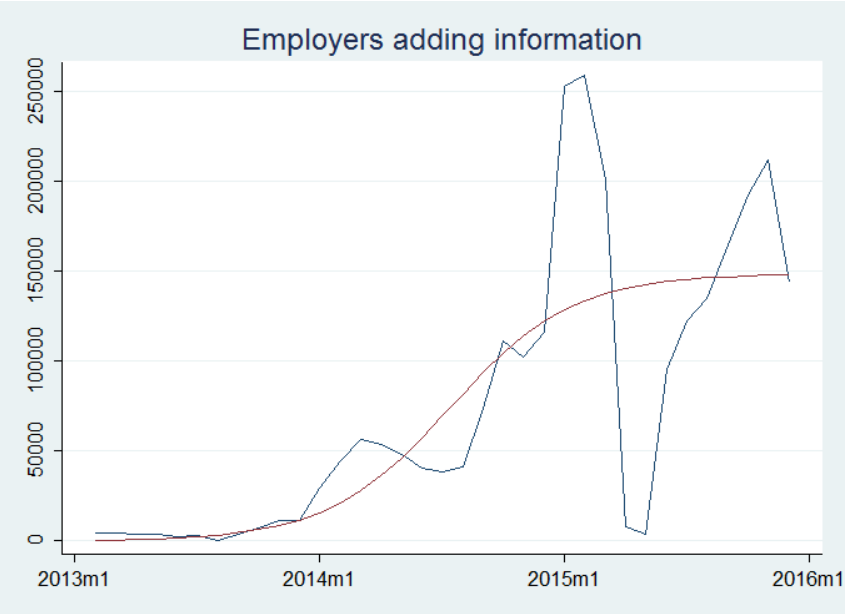


Figure 58. Take-up of service-component "List for employer"

Source: Author's own figure based on X-Road data, monthly aggregated

Take-up of service-component "List for employer", which is when employer submits additional information about employee, can be clearly described by S-curve (function of take-up that is S-shaped). Slow take-up in 2013-2014 is followed by considerable jump in 2015 and slower increasing dynamics afterwards.

Fitting logistic function to the data of the service-component "List for person" (see Annex 7) leads to the following function:

qperday=1312/[1+exp(-0,03*(monthyear - 577))]

β_1 and β_3 are statistically significant, but β_2 is not statistically significant at 95% confidence level.

The estimation explains 85% of variance of the data.

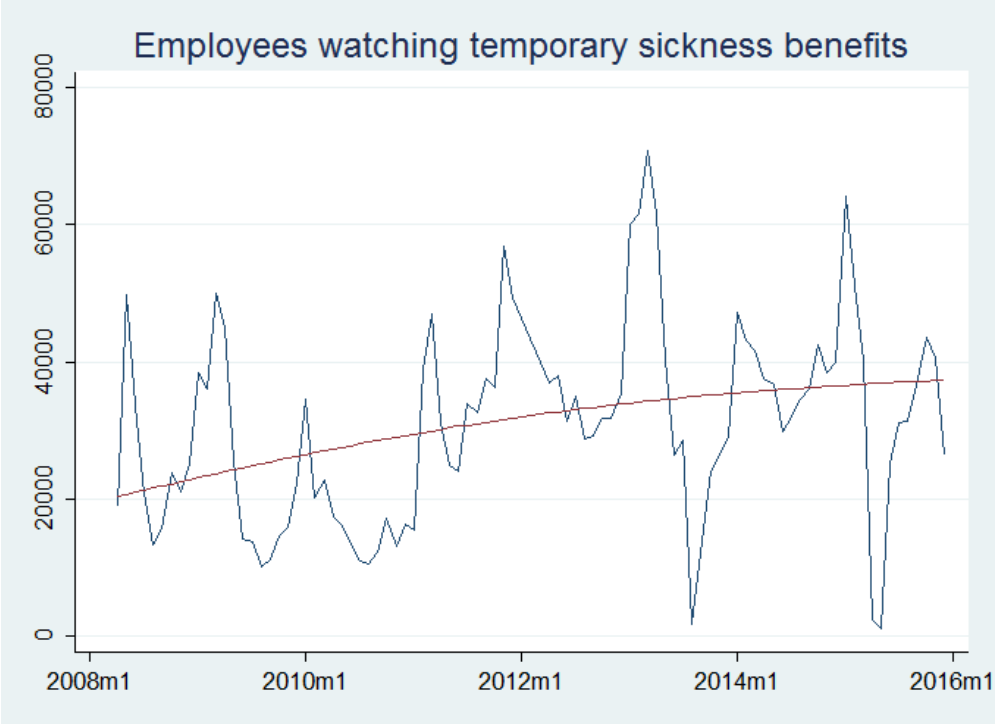


Figure 69. Take-up of service-component "List for person"

Source: Author's own figure based on X-Road data, monthly aggregated

From the above graph (Figure 19) we can see that take-up of E-TVL e-service by employees (in terms of using electronic state portal in order to check their temporary sickness benefits) is rather slow. We observe increasing dynamics of number of queries to check benefits, however the increase is very mild.

Figure 18 illustrates ratio between individuals who use E-TVL service and recipients of sickness benefits. We can see from the graph that older men and women less frequently check their benefits online than younger people. Besides, clear gender pattern is observed for employees: women of age group 20-30 y. o. on average access online portal 3 times more frequent than men (Figure 20).

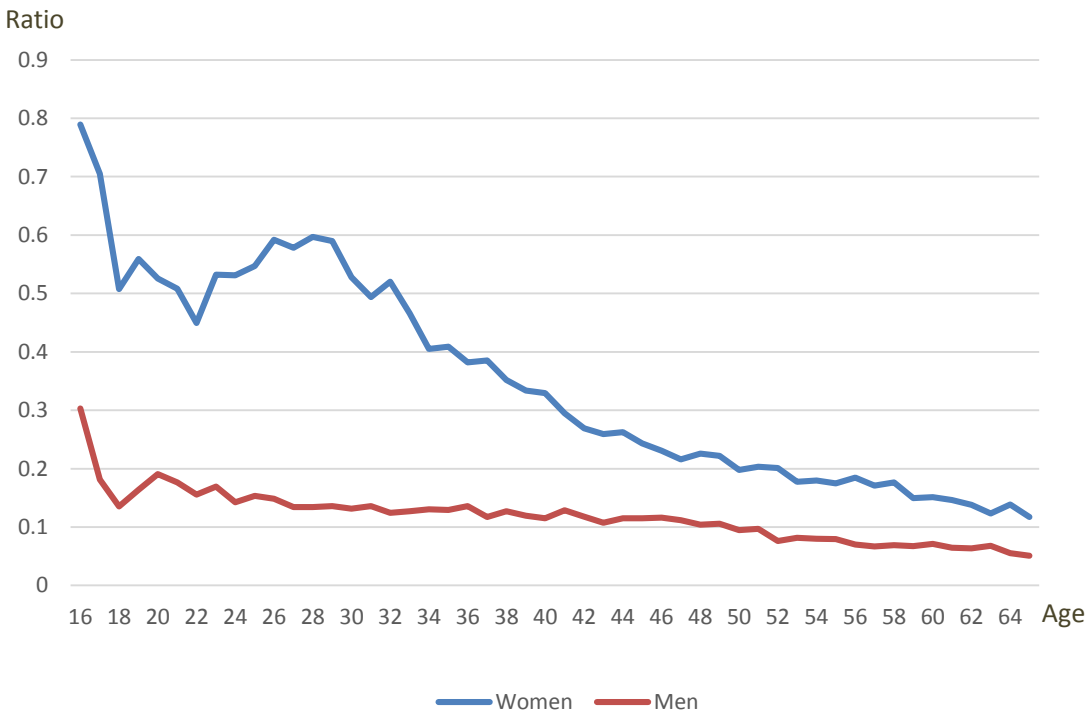


Figure 20. Individuals who use E-TVL service per recipient of sickness benefit, by age
Source: X-Road data, data on sickness benefit recipients from EHIF

Results from this subsection demonstrate that doctors have the fastest take-up among all participants involved in the system of electronic sickness certificates. E-TVL service has reached full take-up as nearly 100% of doctors issue electronic certificates in Estonia now. In terms of adoption by employees: older men and women less frequently check their benefits online than younger people. Besides, clear gender pattern is observed for employees: women of age group 20-30 y. o. on average access online portal 3 times more frequent than men. Take-up of E-TVL by employees is rather slow and have not yet reached full adoption.

4.3 Explanation of the use of electronic services

In this section we analyze if there is a connection between change in the number of queries of E-TVL service and various factors (age and gender of individuals, calendar months, type of service etc.).

Poisson model is used to model count data, in which the observations have only non-negative integer values {0, 1, 2, 3, …} and these values come from counting rather than ranking. Our dependent variable is the number of queries made by users and it takes non-negative integer values and counts the number of queries per person ID, therefore we will use Poisson estimation in our analysis.

We estimate Poisson model separately for monthly data for the service "List for doctor" and for daily data. In the monthly model, dependent variable is number of queries, which is calculated as a sum of queries for each month.

Service "List for doctor" implies for doctors either creating a new electronic sickness benefit certificate or checking existing certificates. This service is based on patient information. A doctor enters person's personal code and receives information on existing certificates.

If we fit a function to our data for the service "List for doctor", we clearly see a non-linear relationship (Figure 21).

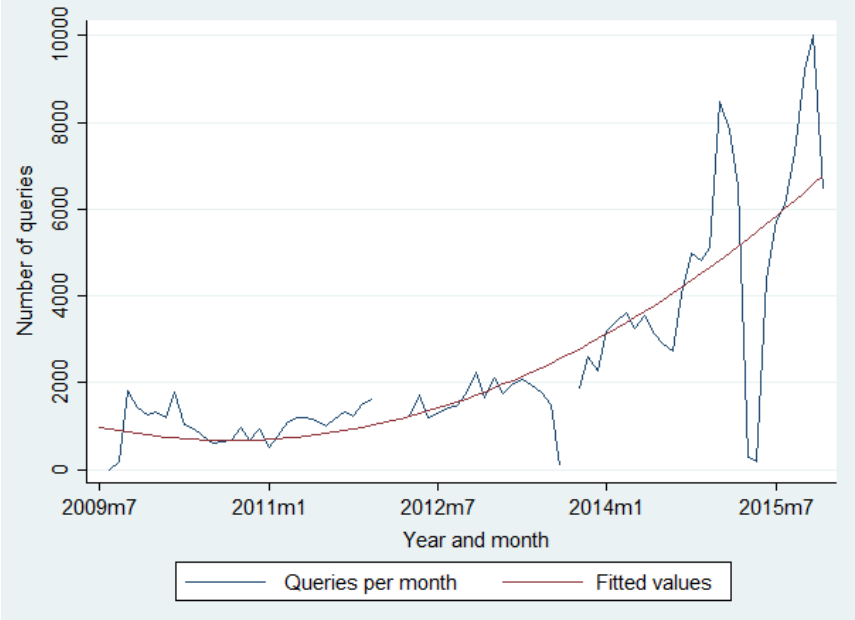


Figure 21. Non-linear dependence of number of queries per month and time

Source: Author's own figure based on X-Road data, monthly aggregated

Table 3 provides Poisson estimation results for service-component "List for doctor" using monthly aggregated data. In the following Poisson regression we also used option of exposure in order to take into account the logging problem, that is when the logging system was down (Annex 1). Therefore, we applied exposure of variable of number of days logging worked. In Table 3 we presented exponentiated coefficients of regression, which are incidence rate ratios[4] (IRR).

Results demonstrate that there is non-linear effect with the age. Initially, as doctors get older, the average number of queries is expected to rise, but from certain age onwards,

[4] Incidence rate ratio (IRR) – how many times the expected value increases when explanatory variable changes by one unit.

age 50-55 the total number of queries will start to decline. This can be interpreted as doctors of middle age are more experienced and tend to have more patients than doctors of younger age. There is only 1 percentage point difference of expected number of queries for men compared to women, which indicates that gender is not relevant factor for doctors and do not influences number of issued electronic certificates.

Table 3. Poisson estimation results for service-component "List for doctor"

	queries
queries	
age	1.843***
	(6.17)
c.age#c.age	0.994***
	(-6.41)
male	0.0199***
	(-18.12)
January	1
	(.)
Februry	0.993
	(-0.64)
March	0.841***
	(-15.07)
April	0.567***
	(-42.42)
May	0.581***
	(-40.27)
June	0.593***
	(-43.28)
July	0.574***
	(-46.71)
August	0.587***
	(-43.63)
September	0.674***
	(-34.00)
October	0.819***
	(-18.37)
November	0.862***
	(-13.50)
December	0.656***
	(-37.84)
monthyear	0.661***
	(-43.66)
c.monthyear#c.m onthyear	1.000***
	(46.80)
_cons	6.34082e+48***
	(37.81)
N	75

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's estimation based on X-Road data aggregated monthly, service "List for doctor"
Note: Poisson regression with exponentiated coefficients

Table 4. Poisson regression estimation results for doctors: Poisson regression (1), Poisson regression for men (2), Poisson regression for women (3)

	(1) Number of queries per day	(2) Number of queries per day	(3) Number of queries per day
Number of queries per day			
age	0.989***	0.947***	0.994***
	(-8.02)	(-13.84)	(-3.94)
age # age	1.000***	1.000***	1.000*
	(5.15)	(9.71)	(2.33)
male	1.113***		
	(13.32)		
January	1	1	1
	(.)	(.)	(.)
February	0.959***	0.781***	0.981
	(-3.64)	(-7.10)	(-1.60)
March	0.953***	0.804***	0.973*
	(-4.19)	(-6.18)	(-2.28)
April	0.928***	0.842***	0.937***
	(-5.59)	(-4.32)	(-4.58)
May	0.896***	0.609***	0.934***
	(-8.29)	(-11.75)	(-4.85)
June	0.862***	0.586***	0.897***
	(-12.30)	(-13.99)	(-8.49)
July	0.874***	0.642***	0.905***
	(-11.20)	(-11.85)	(-7.85)
August	0.891***	0.627***	0.926***
	(-9.43)	(-12.22)	(-5.97)
September	0.875***	0.629***	0.906***
	(-11.51)	(-12.61)	(-8.03)
October	0.905***	0.619***	0.944***
	(-9.38)	(-14.48)	(-5.15)
November	0.937***	0.661***	0.974*
	(-6.20)	(-12.94)	(-2.33)
December	0.925***	0.650***	0.961***
	(-7.12)	(-12.84)	(-3.41)
Sunday	1	1	1
	(.)	(.)	(.)
Monday	0.915**	1.056	0.869***
	(-3.13)	(0.91)	(-4.33)
Tuesday	0.931*	1.187**	0.877***
	(-2.50)	(2.87)	(-4.03)
Wednesday	0.915**	1.073	0.868***
	(-3.11)	(1.17)	(-4.35)
Thursday	0.909***	1.105	0.858***
	(-3.33)	(1.67)	(-4.70)
Friday	0.940*	1.158*	0.886***
	(-2.19)	(2.47)	(-3.72)
Saturday	0.897*	0.836*	0.928
	(-2.55)	(-2.10)	(-1.50)
monthyear	1.038***	0.728***	1.074***
	(4.79)	(-12.73)	(8.86)
monthyear # monthyear	1.000***	1.000***	1.000***
	(-4.94)	(12.82)	(-9.05)
Constant	0.0000353***	4.35208e+44***	5.53e-10***
	(-4.18)	(12.94)	(-8.27)
Observations	95983	8296	87687

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's estimation based on X-Road data aggregated daily, service "List for doctor"

Note: Poisson regression with exponentiated coefficients

Estimating Poisson regression for daily data allows including also personal characteristics: age, gender etc.

In Table 5 presented Poisson regression estimation results for doctors based on daily data, where the following five age groups are added: 20-30 years old, 30-40 years old, 40-50 years old, 50-60 years old, 60-70 years old.

From the histogram below (Figure 22), we can see that majority of doctors make on average one query per day. In other words, doctors access information system of E-TVLs once per day.

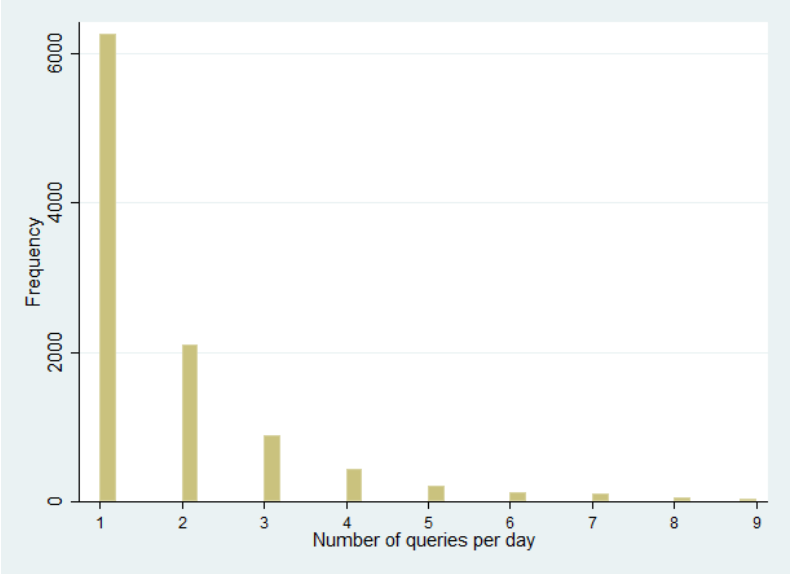


Figure 22. Number of times doctors access E-TVL per day

Source: Author's diagram based on X-Road data aggregated daily, service "List for doctor"

If we look at how the age structure of doctors changed over time, who write electronic health certificates, then we will see that the share of those aged 60 or more increased (Figure 23).

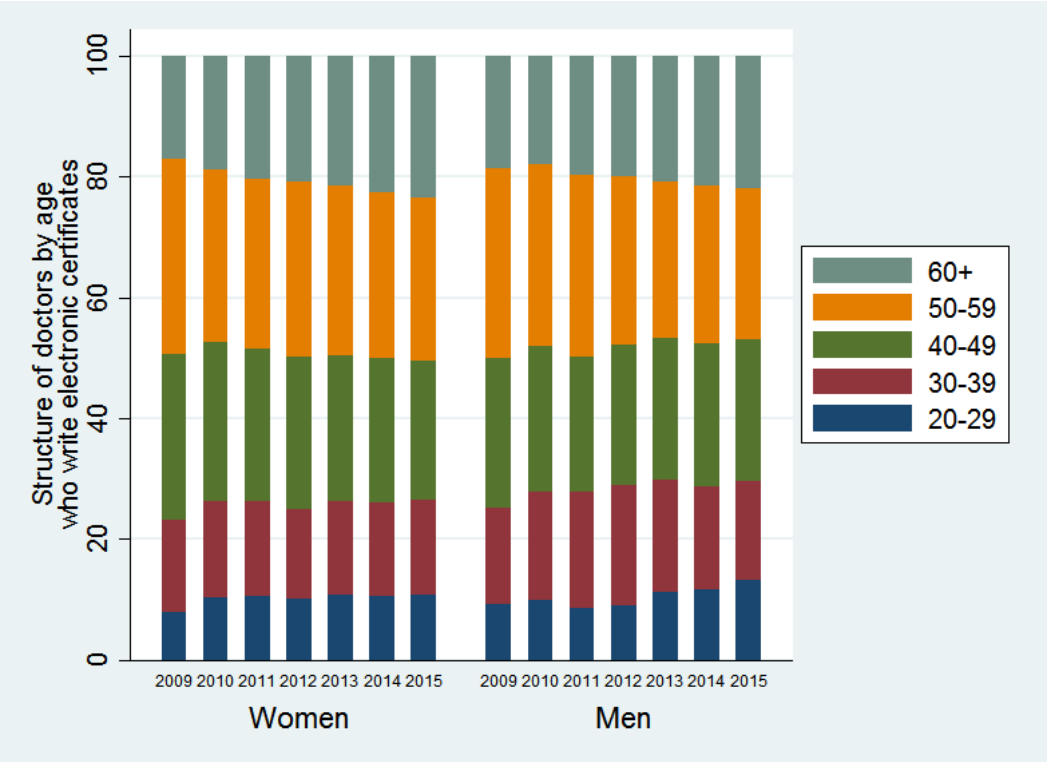


Figure 23. Age structure of doctors-users of ETVL by gender (2009-2015)

Source: Author's diagram based on X-Road data

Provided that women take more often caring leaves and receive maternity benefits, we estimate Poisson regressions as well separately for male and female employees (compared in ANNEX 8). Results for men and women are quite different. Particularly, results for the age groups 50-60 and 60-70 years old show that if man is older, the number of queries is expected to decrease compared to younger. However, for women situation is the opposite: if woman is of age 50-70 years old the number of queries is expected to increase compared to younger. If individual is male, the number of queries is expected to be lower compared to females.

To sum up, the older the age of doctors is the more queries they tend to make and use electronic certificates. On the hand, the take-up of electronic services in the older age groups of doctors was slower. Gender is not relevant factor in case of doctors. Female employees of age 50-70 years look their benefits more frequently than younger ones, whereas male employees of these age group – less frequently than younger.

Table 5. Poisson regression estimation results for doctors with age groups included: Poisson regression (1), Poisson regression for men (2), Poisson regression for women (3)

	Number of queries per day (1)	Number of queries per day (2)	Number of queries per day (3)
Number of queries per day			
age5=20	1	1	1
	(.)	(.)	(.)
age5=30	1.021*	1.867***	0.919***
	(2.05)	(21.67)	(-7.60)
age5=40	0.939***	0.866***	0.946***
	(-6.63)	(-4.69)	(-5.57)
age5=50	0.896***	0.854***	0.896***
	(-11.88)	(-5.14)	(-11.39)
age5=60	0.890***	0.881***	0.891***
	(-12.09)	(-4.05)	(-11.37)
male	1.112***		
	(13.12)		
January	1	1	1
	(.)	(.)	(.)
February	0.959***	0.807***	0.980
	(-3.63)	(-6.18)	(-1.67)
March	0.954***	0.824***	0.972*
	(-4.14)	(-5.48)	(-2.34)
April	0.928***	0.864***	0.936***
	(-5.54)	(-3.67)	(-4.64)
May	0.896***	0.593***	0.934***
	(-8.26)	(-12.38)	(-4.91)
June	0.862***	0.585***	0.897***
	(-12.29)	(-14.03)	(-8.51)
July	0.874***	0.633***	0.905***
	(-11.20)	(-12.22)	(-7.90)
August	0.891***	0.632***	0.924***
	(-9.42)	(-12.00)	(-6.07)
September	0.875***	0.630***	0.905***
	(-11.47)	(-12.59)	(-8.14)
October	0.905***	0.626***	0.942***
	(-9.31)	(-14.17)	(-5.25)
November	0.938***	0.671***	0.973*
	(-6.08)	(-12.48)	(-2.44)
December	0.927***	0.670***	0.961***
	(-6.97)	(-11.96)	(-3.46)
Sunday	1	1	1
	(.)	(.)	(.)
Monday	0.915**	1.106	0.871***
	(-3.13)	(1.70)	(-4.26)
Tuesday	0.931*	1.242***	0.879***
	(-2.51)	(3.63)	(-3.96)
Wednesday	0.915**	1.102	0.870***
	(-3.13)	(1.61)	(-4.27)
Thursday	0.909***	1.148*	0.860***
	(-3.34)	(2.30)	(-4.62)
Friday	0.939*	1.183**	0.888***
	(-2.21)	(2.83)	(-3.65)
Saturday	0.896*	0.845*	0.928
	(-2.55)	(-1.97)	(-1.50)
monthyear	1.037***	0.686***	1.074***
	(4.78)	(-15.23)	(8.81)
monthyear # monthyear	1.000***	1.000***	1.000***
	(-4.92)	(15.32)	(-9.01)
Constant	0.0000274***	1.66369e+52***	5.57e-10***
	(-4.28)	(15.24)	(-8.26)
Observations	95981	8294	87687

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's estimation based on X-Road data aggregated daily, service "List for doctor"

Note: Poisson regression with exponentiated coefficients

Discussion

Measuring the impact of e-government is a challenging task. There are several difficulties that we need to be aware of beforehand when dealing with e-government evaluation. First of all, concept of e-governance is very complex, therefore it is hard to provide assessment that will cover all aspects of it. Secondly, to achieve e-government goals cross-agency efforts are in place, which makes it difficult to differentiate between inputs of various agencies. Thirdly, besides financial (quantifiable) aspects there is also quality dimension of impact, which needs to be accounted for too. For these reasons, it is challenging to find mutually exclusive measurement indicators.

Moreover, there is usually a lot of cooperation and collaboration between several agencies and across services in e-government projects. It can also involve organizational restructuring and business process reengineering (Lau, 2005, p.3). Therefore, it can be not always possible to split up and precisely allocate the direct and indirect benefits of e-government services to between government and users.

In the discussion part we would like also to include illustrative example of possible assessment of costs that are potentially saved upon implementation of E-TVL e-service. For simplicity, calculations are done only for the 2015 year as this is the year when all certificates for temporary incapacity for work were issued electronically. Selection of 2015 is done in order to ensure that number of sickness benefits is the same as the number of electronic certificates issued.

In 2015 there were 358705 benefits for temporary incapacity for work in total. Provided that from 1st January 2015 all employers were obliged to submit sickness leaves related data electronically, this figure of 358705 benefits represents number of electronically issued certificates. That means that employers did not have to send paper documents to the EHIF by post, which in 2015 saved approximately 304899 € to all Estonian employers cumulatively:

Number of benefits postal cost = 358705 × 0,85€[5] = 304899,25 €

Therefore, compared with situation where there was usual service with paper workflow, e-service saves at least around 304899 € per year (by eliminating postal costs).

Let us calculate the Total Value Potential (TVP) of the service by first taking into account doctors as a group. TVP is calculated according to the following formula:

TVPi(t)=population groupi ×unit benefit [U]×conversion [€/U]×occurence (t)

Number of doctors: 2574 doctors accessed e-service in 2015

[5] Minimum postal price including stamp and envelope (e-shop of Eesti Post, http://pood.post.ee).

Unit benefit: 0.25 working hours are saved on average by doctor for issue of one E-TVL certificate instead of issuing paper version of it

Assume doctor saves **15 min** = 0.25 hour per certificate

Conversion: **10.78€/hour** (The average hourly basic wage of full-time and part-time physicians in 2015 was 10.78 euros[6]).

Occurrence: **358705** sickness cases in 2015

TVPi(2015) = 10.78€/hour × 0.25 hours × 358705 cases = 966710 € (*)

In 2015, 89676 hours were saved by doctors due to using e-service, which corresponds to saving 966710 € in monetary terms.

Table 6 presents calculation of benefits based on assumption of saved time: 10, 15 and 20 minutes.

Table 6. Calculation of benefits of E-TVL in 2015

Minutes saved	**10 min**	**15 min**	**20 min**
Hours saved	0,17	0,25	0,33
Elimination of postal costs	304899,25	304899,25	304899,25
Elimination of paper and printing costs	107611,50	107611,50	107611,50
Alternative value of doctors' saved time	644473,32	**966709,98 ***	1288946,63
Total value saved	1056984,07	1379220,73	1701457,38
% of GDP[7]	0,00522%	0,00681%	0,00840%

Additionally, after making electronic certificates obligatory less employees are needed at EHIF to deal with sickness benefits documents and payments. Or at least less working hours at EHIF are spent for dealing with sickness benefits because all information is stored and accessed electronically.

If we assume that time of one full-time abstract worker of EHIF is saved, then in such case for one year cumulatively will be saved approximately 1065€ *12= 12780 €.

Employers submit to EHIF additional data of the employees – when done electronically saves working time of accountants/human resources specialists compared to

[6] National Institute for Health Development, 2016 (Accessed March 2017) http://intra.tai.ee//images/prints/documents/148118811651_Hourly_wages_of_health_care_personnel_March_2016.pdf

[7] Estonian GDP at current prices in 2015: 20251,7 mln €

situation when dealing with paper documents. Assuming that submitting to EHIF electronically saves 15 min per employee, then benefit will be:

0.25 hours × 358705 cases × 6.51€/hour[8]=583792,39 €

Taking into account above-mentioned additional benefits for EHIF and employers, in case when doctor saves 15 minutes of time, will result in the following cumulative number of saved money for 2015 year:

Cumulative value saved=1379220,73+12780+583792,39=1975793,12 € or 0,0098% of GDP

This calculation provides example of applying bottom-up approach for quantification of benefits of e-government service E-TVL. This assessment involves several groups with whom benefits are associated: doctors, employers, EHIF. Altogether bottom-up approach enables to aggregate several benefits to various groups and measure total benefits for Estonia as a country or on governmental level. In this section we provided bottom-up calculations for illustrative purposes and it can be noted that it required above-mentioned assumptions.

In order to make calculation of benefits more accurate additional data is needed. Proxy for saved time can be provided from results of surveys, which need to be conducted every year to gather data by asking doctors and employers about their usage of service. Furthermore, for purposes of cost-benefit analysis or cost-effectiveness analysis, expenditures of implementation of e-government initiative need to be estimated as well. It is of highly importance to record data about costs and it needs to be done as precise as possible: separately record costs of launching certain programme and separately proceeding costs of the service "maintenance" per year, including information how many people (employees) were involved and labour costs. This data will enable to measure inputs, which in turn is necessary for calculation of efficiency as it is input-output ratio.

[8] Average hourly gross wage in 2015 (http://www.stat.ee/news-release-2016-024, Accessed March 2017).

Conclusions

Assessment of e-government benefits is becoming a growing priority for governors, however there is not much progress so far in the development of appropriate measurement techniques. A number of studies (Berntzen, 2014; Codagnone and Undheim, 2008; Aichholzer, 2005) mention that impact evaluation of e-government services remains largely an under-researched topic. No consensus has been reached about how to measure effects of implementation of e-government initiatives. From one point, not all of the effects and results of e-government are clearly visible. From other point, complexity behind concept of e-governance makes it hard to determine evaluation framework that can cover all aspects of e-government.

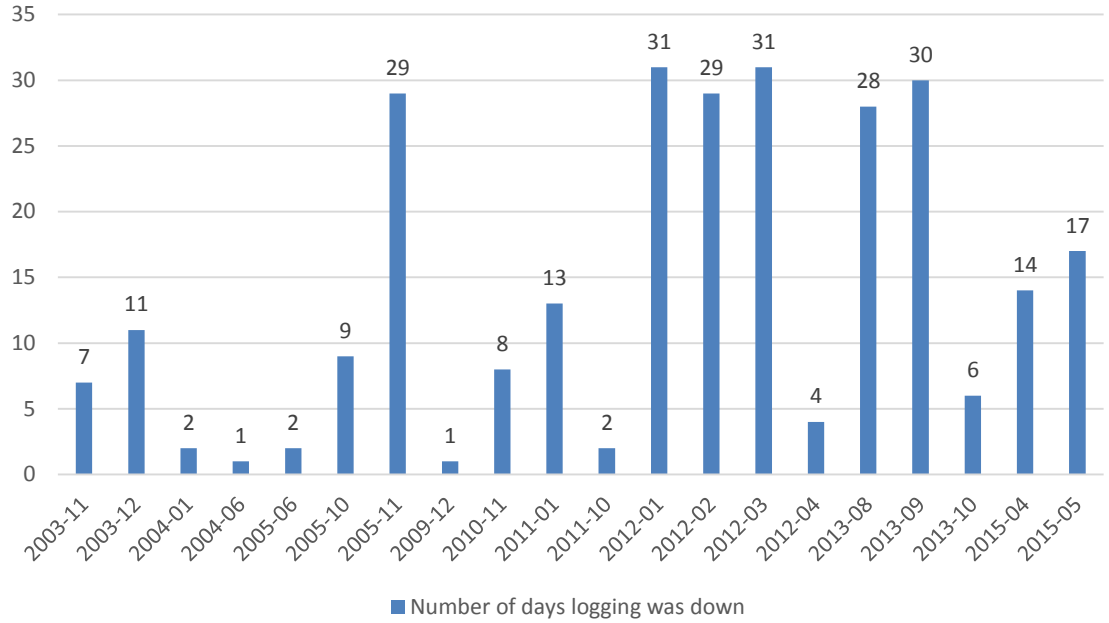
Empirical part concentrates on measuring and explaining take-up of electronic certificates for incapacity to work in Estonia. Analysis of take-up of different service-components of E-TVL demonstrate that doctors have the fastest take-up among all participants involved in the system of electronic sickness certificates. E-TVL service has reached full take-up as nearly 100% of doctors issue electronic certificates in Estonia now. In terms of adoption by employees: older men and women less frequently check their benefits online than younger people. Besides, clear gender pattern is observed for employees: women of age group 20-30 y. o. on average access online portal 3 times more frequent than men. Take-up of E-TVL by employees is rather slow and have not yet reached full adoption.

Poisson regressions estimation results show the older the age of doctors is the more queries they tend to make and use electronic certificates. On the hand, the take-up of electronic services in the older age groups of doctors was slower. Gender is not relevant factor in case of doctors. Female employees of age 50-70 years look their benefits more frequently than younger ones, whereas male employees of these age group – less frequently than younger.

In order to provide proper measurement of impact of e-government services, more accurate data is needed about saved time due to use of electronic forms as well as data about costs for implementing the initiative and associated labour costs.

Annexes

ANNEX 1 Number of days logging system was down

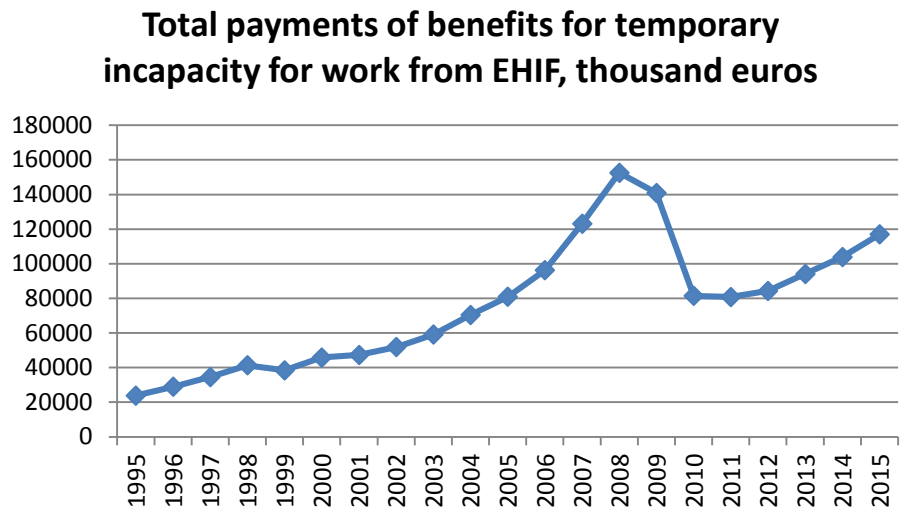


ANNEX 2 Distribution of age of physical persons

Age, years old	Number of individuals	Percentage
<20	22037	8%
20-29	103015	36%
30-39	68930	24%
40-49	44050	15%
50-59	31845	11%
60-70	11980	4%
>70	2476	1%
Total	284333	100%

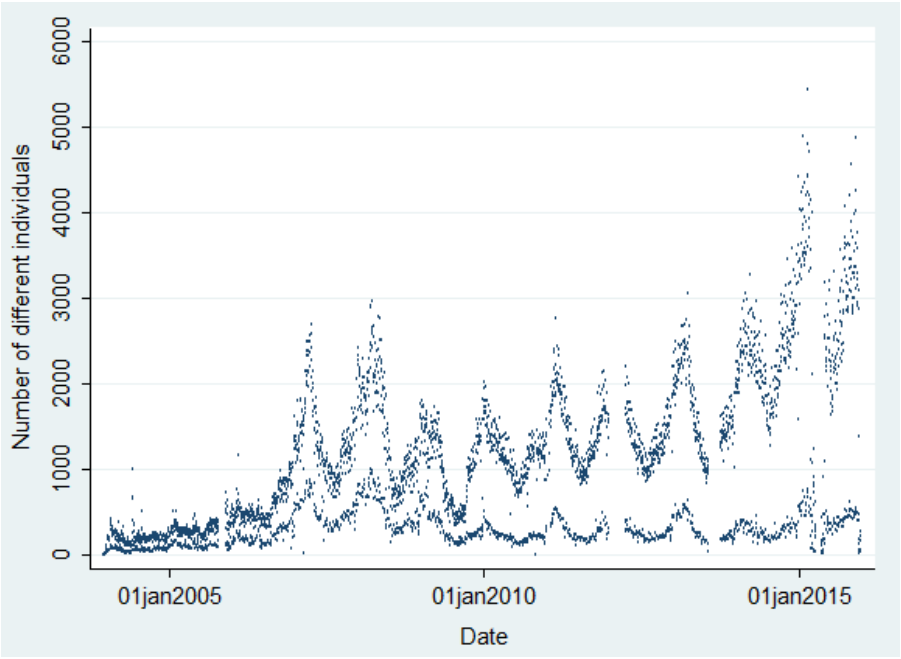
Source: Author's own calculations based on X-Road data

ANNEX 3 Total payments of benefits by EHIF (1995-2015)



Source: Author's own figure based on Statistics Estonia data

ANNEX 4 Number of different individuals who accessed e-service, daily



Source: Author's own calculations based on X-Road data

ANNEX 5 Number of employees checking sickness benefits online

Year	Number of people checking benefits online
2008	57505
2009	55035
2010	40686
2011	46646
2012	37945
2013	48381

2014	52665
2015	56319
Average	49398

ANNEX 6 Estimated parameters for logistic function based on the data of service-component "List for employer"

Source	SS	df	MS		
Model	345626550	3	115208850	Number of obs	49
Residual	95640244.5	46	2079135.75	R-squared	0.7833
				Adj R-squared	0.7691
Total	441266794	49	9005444.78	Root MSE	1441.921
				Res. dev.	848.7859

3-parameter logistic function, qperday = b1/(1 + exp(-b2*(monthyear - b3)))

qperday	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
/b1	4948.12	568.0794	8.71	0.000	3804.635	6091.605
/b2	.3325196	.1488798	2.23	0.030	.03284	.6321992
/b3	654.3955	1.60833	406.88	0.000	651.1581	657.6329

ANNEX 7 Estimated parameters for logistic function based on the data of service-component "List for person"

Source	SS	df	MS		
Model	97137297.5	3	32379099.2	Number of obs	89
Residual	16666782.4	86	193799.796	R-squared	0.8535
				Adj R-squared	0.8484
Total	113804080	89	1278697.53	Root MSE	440.227
				Res. dev.	1333.057

3-parameter logistic function, qperday = b1/(1 + exp(-b2*(monthyear - b3)))

qperday	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
/b1	1311.991	276.3796	4.75	0.000	762.566	1861.415
/b2	.0310281	.0276219	1.12	0.264	-.0238825	.0859387
/b3	576.5851	12.55555	45.92	0.000	551.6255	601.5447

ANNEX 8. Poisson regression estimation results for individuals: Poisson regression (1), Poisson regression for men (2), Poisson regression for women (3)

	(1) Number of queries per day	(2) Number of queries per day	(3) Number of queries per day
Number of queries per day			
age5=20	1	1	1
	(.)	(.)	(.)
age5=30	0.941***	0.905***	0.947***
	(-40.56)	(-33.21)	(-31.19)
age5=40	0.940***	0.839***	0.972***
	(-32.23)	(-47.95)	(-12.53)
age5=50	1.180***	0.815***	1.316***
	(81.30)	(-46.42)	(119.51)
age5=60	1.392***	0.782***	1.641***
	(117.94)	(-37.64)	(159.10)
male	0.818***		
	(-142.82)		
January	1	1	1
	(.)	(.)	(.)
February	0.968***	1.023***	0.947***
	(-11.61)	(4.09)	(-16.47)
March	0.975***	1.012*	0.959***
	(-9.38)	(2.24)	(-13.10)
April	0.940***	0.980***	0.925***
	(-21.91)	(-3.61)	(-23.77)
May	0.980***	0.930***	0.994
	(-7.13)	(-12.50)	(-1.74)
June	1.010***	0.928***	1.037***
	(3.47)	(-12.22)	(10.44)
July	1.108***	0.975***	1.146***
	(34.57)	(-4.16)	(40.30)
August	1.126***	1.005	1.159***
	(37.27)	(0.81)	(40.60)
September	1.124***	1.007	1.157***
	(37.64)	(1.07)	(41.15)
October	1.056***	1.015*	1.064***
	(19.07)	(2.56)	(18.61)
November	1.032***	1.010	1.036***
	(11.27)	(1.70)	(10.66)
December	1.006*	0.992	1.008*
	(2.21)	(-1.43)	(2.40)
Sunday	1	1	1
	(.)	(.)	(.)
Monday	1.350***	1.225***	1.395***
	(99.56)	(36.99)	(91.83)
Tuesday	1.329***	1.199***	1.376***
	(93.73)	(32.83)	(87.58)
Wednesday	1.326***	1.206***	1.369***
	(92.45)	(33.54)	(85.79)
Thursday	1.323***	1.220***	1.359***
	(90.94)	(35.34)	(83.10)
Friday	1.307***	1.221***	1.338***
	(85.48)	(34.84)	(77.70)
Saturday	1.006	1.010	1.006
	(1.54)	(1.39)	(1.23)
monthyear	1.196***	1.042***	1.254***
	(152.82)	(17.88)	(165.57)
monthyear # monthyear	1.000***	1.000***	1.000***
	(-148.15)	(-16.11)	(-161.24)
Constant	1.59e-25***	0.00000125***	4.51e-32***
	(-156.23)	(-19.03)	(-168.97)
Observations	1399013	408253	990760

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's estimation based on X-Road data aggregated daily, service "List for person"

Note: Poisson regression with exponentiated coefficients

References

Aichholzer, Georg. (2005). Service Take-Up and Impacts of E-Government in Austria. In Wimmer, M. et al. (eds.). Electronic Government, Proceedings 4th International Conference EGOV 2005. Lecture Notes in Computer Science 3591, Springer. 2005, pp. 93-104.

Berntzen, Lasse. (2014). Measuring the Impact of eGovernment Services. ICDS 2014 : The Eighth International Conference on Digital Society.

Codagnone, Cristiano, and **Trond Arne Undheim**. (2008). Benchmarking eGovernment: tools, theory, and practice. European Journal of ePractice No 4, August 2008.

Codagnone, Cristiano, Paolo Boccardelli, and **Maria Isabella Leone**. (2006). eGovernment Economics Project (eGEP): Measurement Framework Final Version (2006), eGovernment Unit, DG Information Society, European Commission. Retrieved May 7, 2017 from http://www.umic.pt/images/stories/publicacoes200709/D.2.4_Measurement_Framework_final_version.pdf

Fitsilis, P., Anthopoulos, L., Gerogiannis, V. C.. (2009). Assessment Frameworks of E-Government Projects: a Comparison. PCI 2009 Conference Proceedings.

Gerpott, Torsten J., and Nima Ahmadi. (2016). "Use Levels of Electronic Government Services among German Citizens: An Empirical Analysis of Objective Household and Personal Predictors." Transforming Government: People, Process and Policy 10(4): 637–68.

Glassey, Olivier. (2010). eGovernment: Does IT save time?. 32nd EGPA Annual Conference, Sep 2010, Toulouse, France.

Heeks, Richard. (2006). Understanding and Measuring eGovernment: International Benchmarking Studies, Paper prepared for UNDESA workshop, "E-Participation and E-Government: Understanding the Present and Creating the Future", Budapest, Hungary, 27-28 July 2006.

Intergovernmental Advisory Group (2003). High payoff in electronic government: Measuring the return on eGovernment investments (US General Services Administration, Washington).

Kalvet, Tarmo, and **Tiits, Marek, Hinsberg, Hille** (editors). (2013). Impact assessment of the Estonian e-government services. Tallinn: Institute of Baltic Studies & Praxis Center for Policy Studies.

Lau, Edwin. (2005). E-Government and the drive for growth and equity. Retrieved May 4, 2017 from http://www.belfercenter.org/sites/default/files/legacy/files/lau-wp.pdf

Millard, Jeremy. (2008). eGovernment measurement for policy makers. European Journal of ePractice No 4, August 2008. Retrieved May 7, 2017 from https://joinup.ec.europa.eu/sites/default/files/a8/e0/61/ePractice%20Journal-Vol.4-August%202008.pdf

OECD (2003), The e-Government Imperative, OECD Publishing, Paris.

OECD (2005), e-Government for Better Government, OECD Publishing, Paris.

Rogers, Everett M. *Diffusion of innovations*. 5th edition. Simon and Schuster, 2010.

Savoldelli, Alberto et al. (2013). Measuring the Public value of e-Government: The eGEP2.0 model. *Electronic Journal of e-Government* Volume 11 Issue 1 2013, (pp373- 388), available online at www.ejeg.com.

Stanimirovic, Dalibor, and Vintar, Mirko. (2013). Conceptualization of an Integrated Indicator Model for the Evaluation of e-Government Policies" Electronic Journal of e-Government Volume 11 Issue 2 2013, (pp293-307).

United Nations. Economic Commission for Africa (2014). Manual for measuring e-government. Addis Ababa, 2014.

Van, Der Wee et al. (2015). Identifying and Quantifying the Indirect Benefits of Broadband Networks for E-Government and E-Business: A Bottom-up Approach. Telecommunications Policy 39(3-4): 176–91.

Vassil, Kristjan. (2015). E-Government Ecosystem. Foundation, Applications, Outcomes. Case Study for the World Development Report, World Bank.

Non-exclusive licence to reproduce thesis and make thesis public

I, Kateryna Grygorenko,

1. herewith grant the University of Tartu a free permit (non-exclusive licence) to:

1.1. reproduce, for the purpose of preservation and making available to the public, including for addition to the DSpace digital archives until expiry of the term of validity of the copyright, and

1.2. make available to the public via the web environment of the University of Tartu, including via the DSpace digital archives until expiry of the term of validity of the copyright,

TAKE-UP AND POTENTIAL BENEFITS OF E-GOVERNMENT SERVICES – AN EXAMPLE OF ESTONIAN ELECTRONIC SICKNESS LEAVE CERTIFICATE,

Supervised by Andres Võrk,

2. I am aware of the fact that the author retains these rights.

3. I certify that granting the non-exclusive licence does not infringe the intellectual property rights or rights arising from the Personal Data Protection Act.

Tartu, 25.05.2017